US009473679B2

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Takanashi

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(45) **Date of Patent: Oct. 18, 2016**

(54) **IMAGING APPARATUS AND METHOD FOR CONTROLLING THE SAME, AND LENS UNIT**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventor: **Hideya Takanashi**, Tokyo (JP)

(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Sep. 10, 2013**

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US 2014/0071336 A1 Mar. 13, 2014

(30) **Foreign Application Priority Data**

Sep. 12, 2012 (JP) 2012-200298

(51) **Int. Cl.**

H04N 5/217 (2011.01)
H04N 5/232 (2006.01)
G03B 17/14 (2006.01)

(52) **U.S. Cl.**

CPC ***H04N 5/217*** (2013.01); ***G03B 17/14*** (2013.01); ***H04N 5/23209*** (2013.01); *G03B 2206/00* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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* cited by examiner

Primary Examiner — Mark Monk

(74) *Attorney, Agent, or Firm* — Canon U.S.A., Inc. IP Division

(57) **ABSTRACT**

In an imaging apparatus including a reset instruction unit configured to instruct a lens unit to reset an optical member thereof, a first communication system is used for communication for acquiring individual information of the lens unit, and a second communication system different from the first communication system is used for communication for instructing the lens unit to reset an optical member by a reset instruction unit.

11 Claims, 21 Drawing Sheets

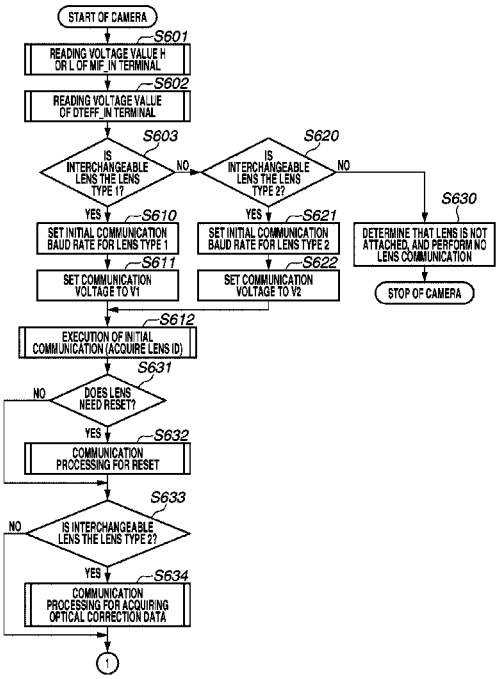


FIG.1

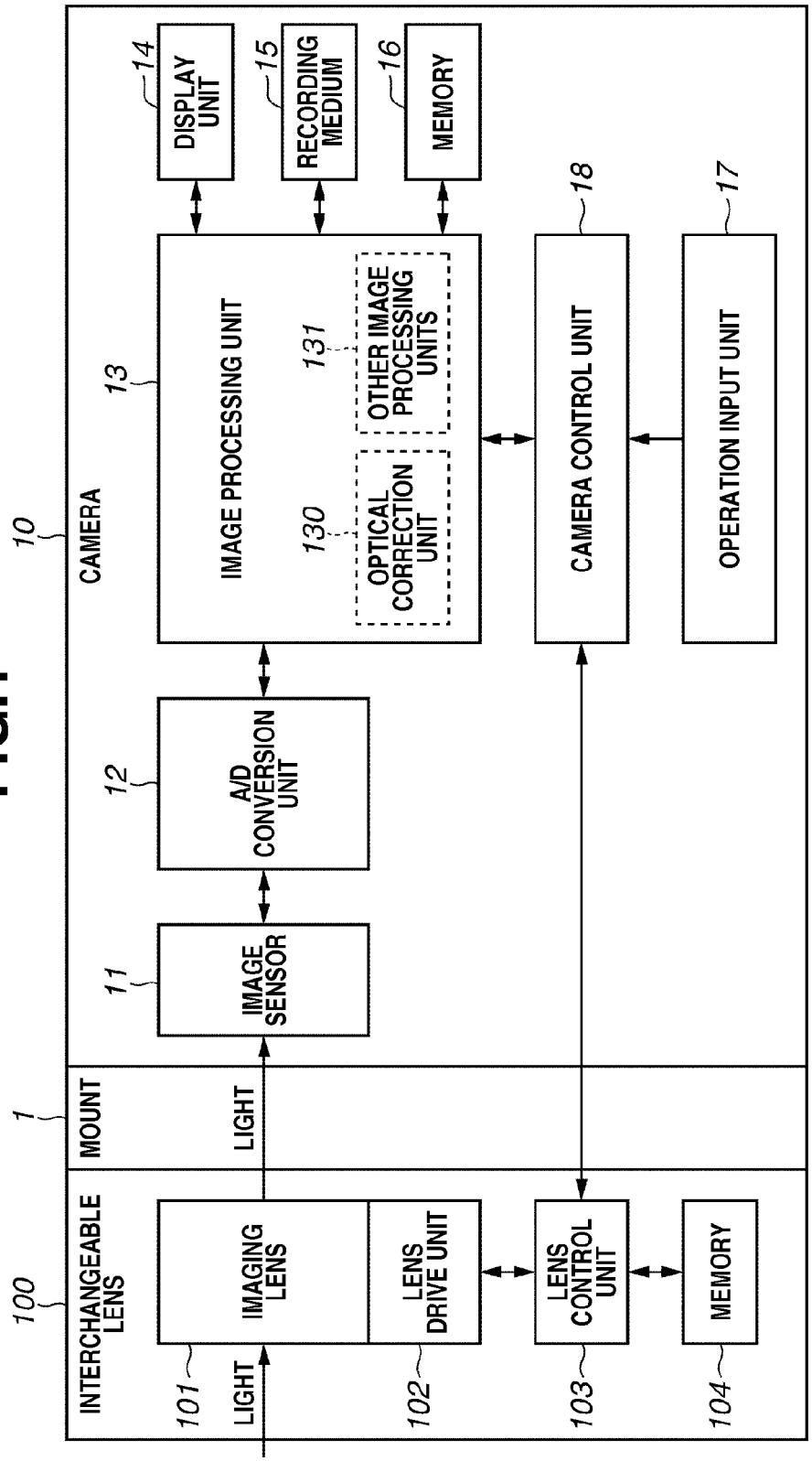

100
INTERCHANGEABLE LENS
101
IMAGING LENS
LIGHT
102
LENS DRIVE UNIT
103
LENS CONTROL UNIT
104
MEMORY
1
MOUNT
LIGHT
10
CAMERA
11
IMAGE SENSOR
12
A/D CONVERSION UNIT
13
IMAGE PROCESSING UNIT
130
OPTICAL CORRECTION UNIT
131
OTHER IMAGE PROCESSING UNITS
14
DISPLAY UNIT
15
RECORDING MEDIUM
16
MEMORY
18
CAMERA CONTROL UNIT
17
OPERATION INPUT UNIT

FIG.2

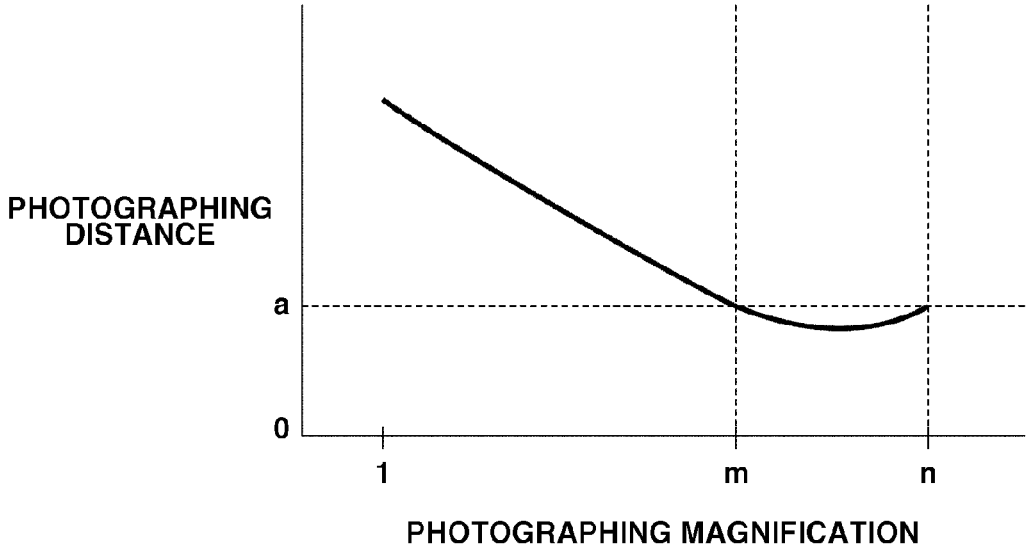

PHOTOGRAPHING DISTANCE
a
0
1
m
n
PHOTOGRAPHING MAGNIFICATION

FIG.3A

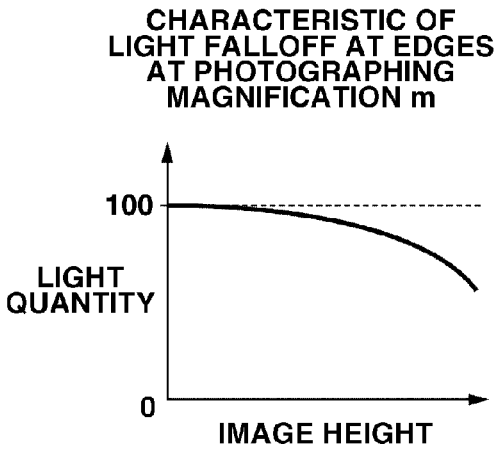


FIG.3B

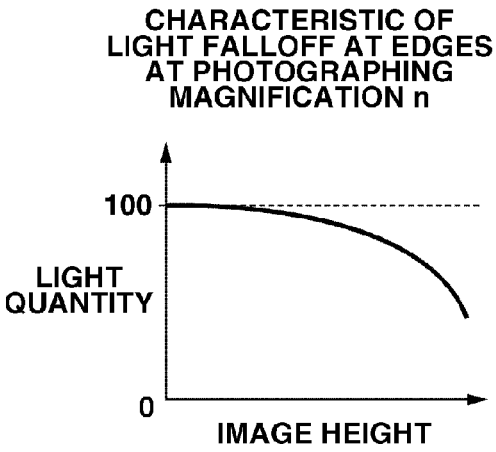


FIG.3C

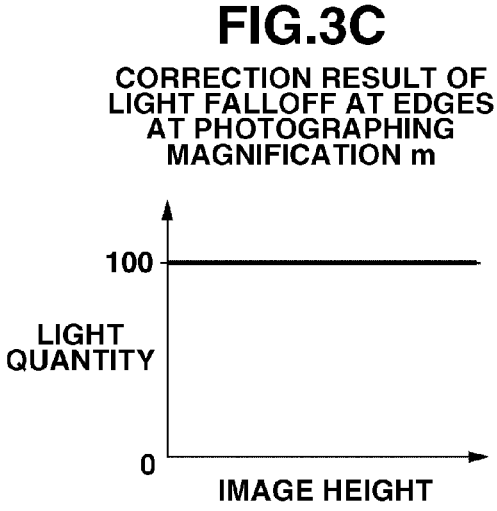


FIG.3D

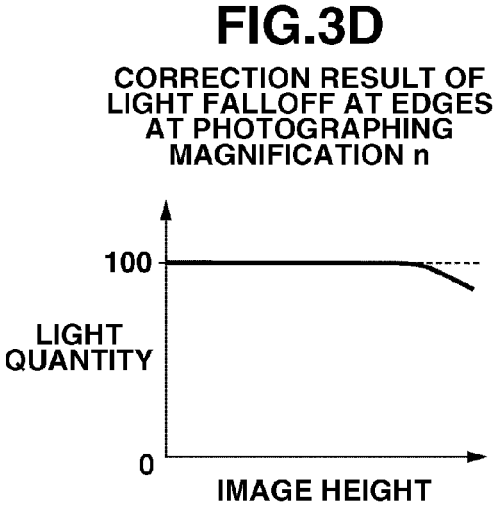


FIG.4

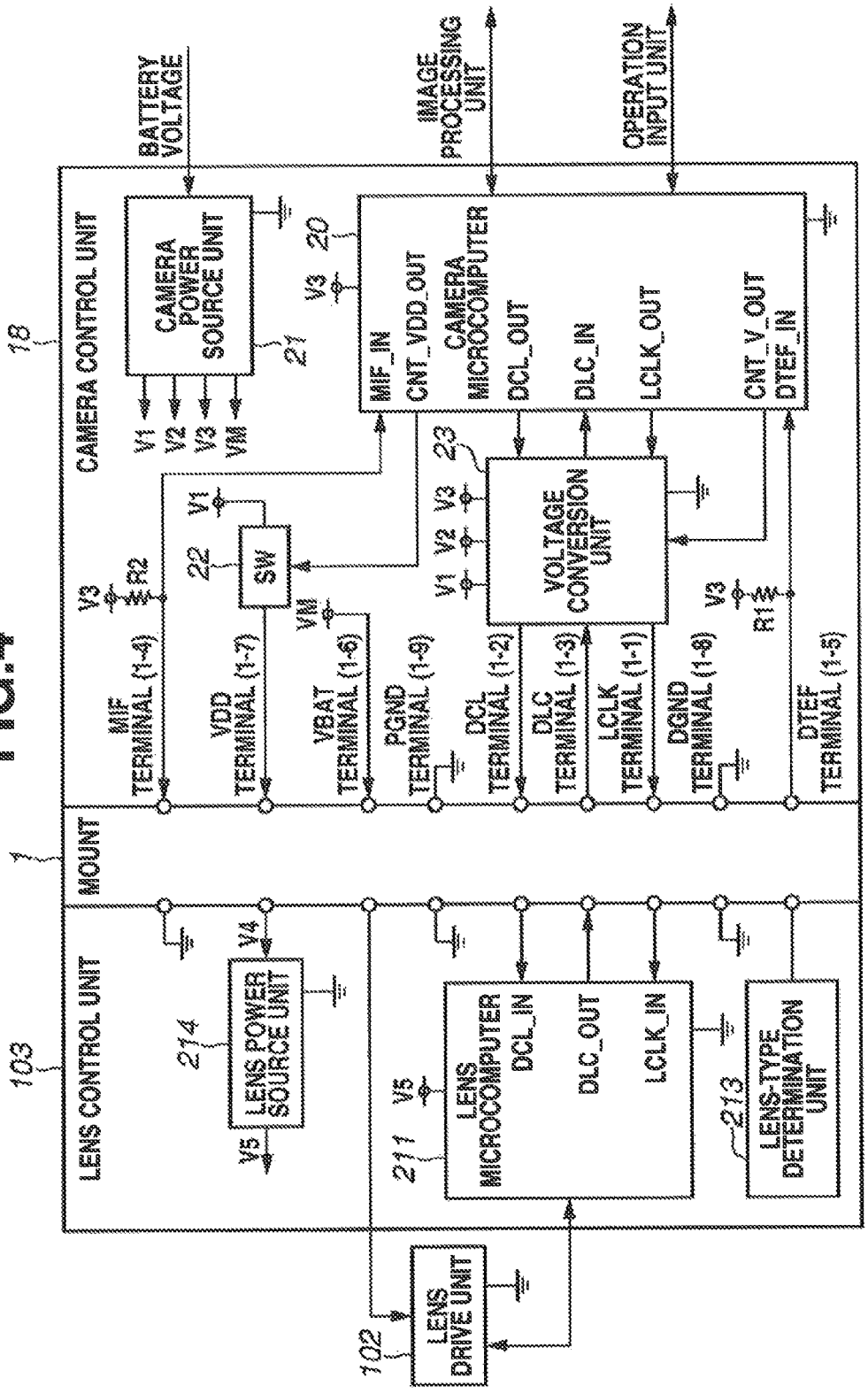

BATTERY VOLTAGE
IMAGE PROCESSING UNIT
OPERATION INPUT UNIT
18
CAMERA CONTROL UNIT
CAMERA POWER SOURCE UNIT
20
21
V3
MIF_IN
CNT_VDD_OUT
CAMERA MICROCOMPUTER
DCL_OUT
DLC_IN
LCLK_OUT
CNT_V_OUT
DTEF_IN
V1
V2
V3
VM
23
VOLTAGE CONVERSION UNIT
22
SW
R2
R1
MIF TERMINAL (1-4)
VDD TERMINAL (1-7)
VBAT TERMINAL (1-6)
PGND TERMINAL (1-9)
DCL TERMINAL (1-2)
DLC TERMINAL (1-3)
LCLK TERMINAL (1-1)
DGND TERMINAL (1-8)
DTEF TERMINAL (1-5)
1
MOUNT
103
LENS CONTROL UNIT
214
LENS POWER SOURCE UNIT
V4
V5
211
LENS MICROCOMPUTER
DCL_IN
DLC_OUT
LCLK_IN
213
LENS-TYPE DETERMINATION UNIT
102
LENS DRIVE UNIT

FIG.5A

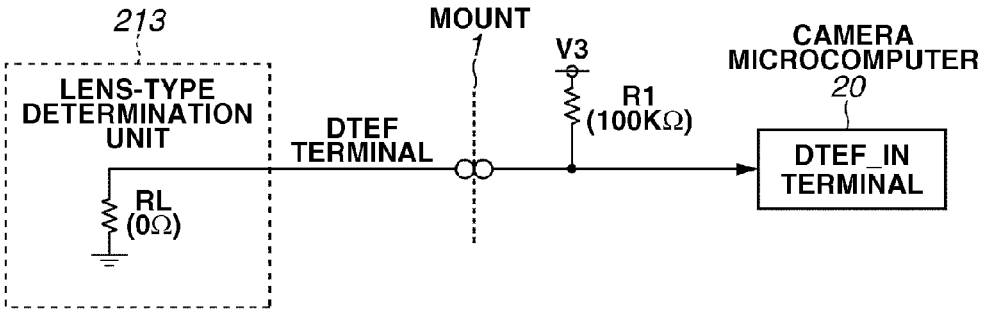

213
LENS-TYPE DETERMINATION UNIT
RL (0Ω)
DTEF TERMINAL
MOUNT
1
V3
R1 (100KΩ)
CAMERA MICROCOMPUTER
20
DTEF_IN TERMINAL

FIG.5B

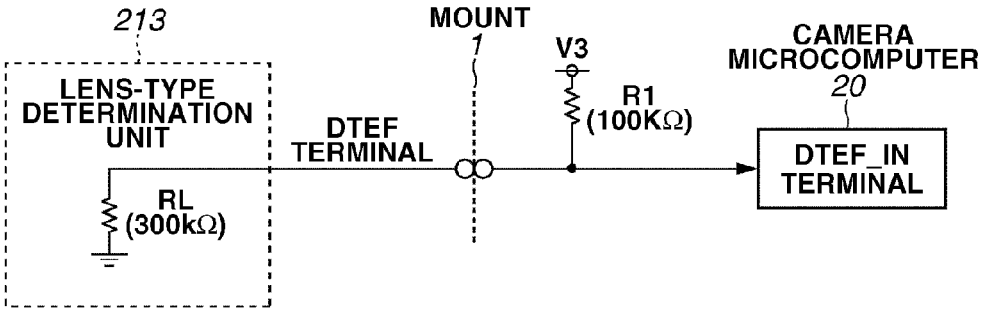

213
LENS-TYPE DETERMINATION UNIT
RL (300kΩ)
DTEF TERMINAL
MOUNT
1
V3
R1 (100KΩ)
CAMERA MICROCOMPUTER
20
DTEF_IN TERMINAL

FIG.6

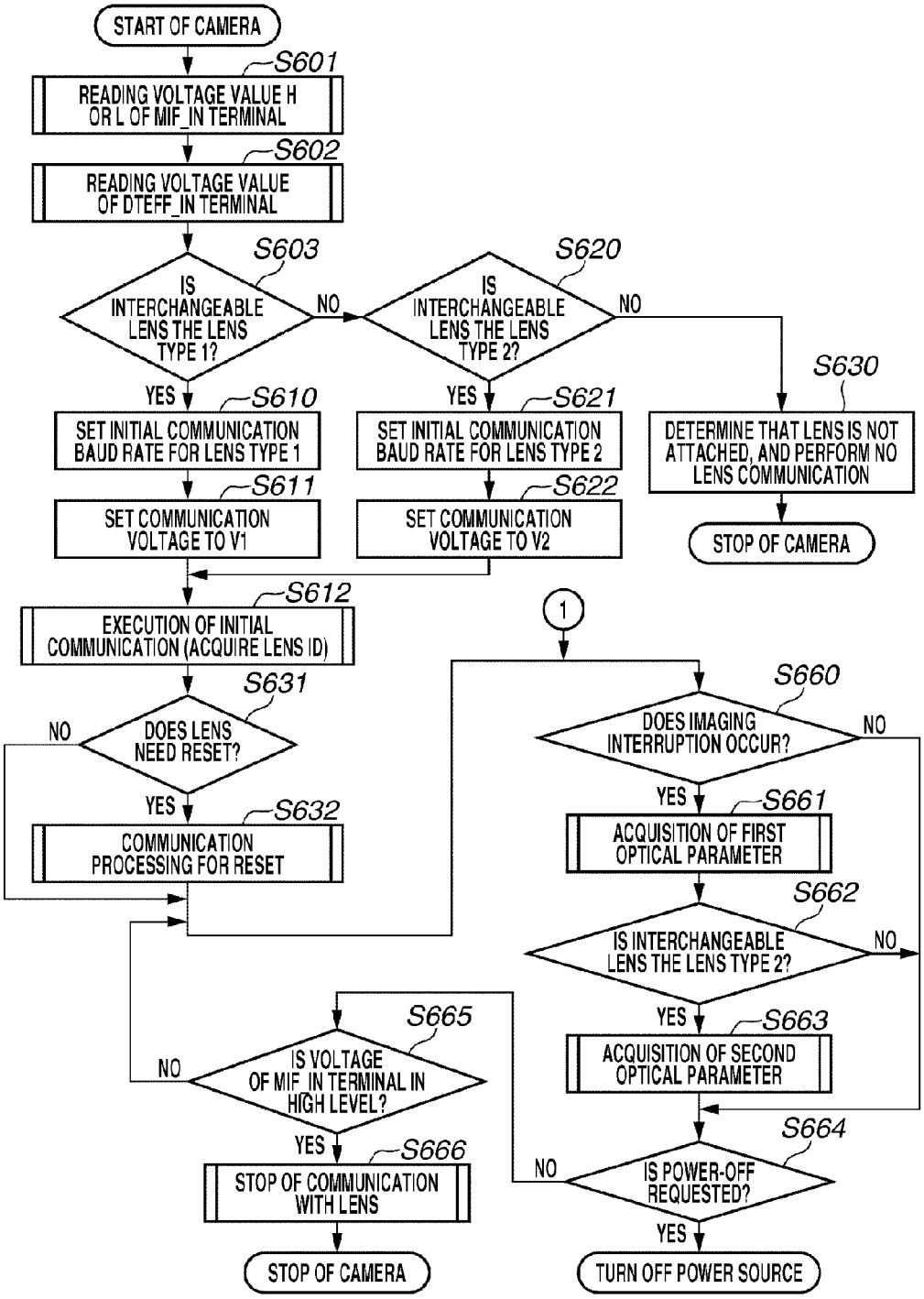

START OF CAMERA
S601
READING VOLTAGE VALUE H OR L OF MIF_IN TERMINAL
S602
READING VOLTAGE VALUE OF DTEFF_IN TERMINAL
S603
IS INTERCHANGEABLE LENS THE LENS TYPE 1?
NO
S620
IS INTERCHANGEABLE LENS THE LENS TYPE 2?
NO
S630
YES
S610
SET INITIAL COMMUNICATION BAUD RATE FOR LENS TYPE 1
S611
SET COMMUNICATION VOLTAGE TO V1
YES
S621
SET INITIAL COMMUNICATION BAUD RATE FOR LENS TYPE 2
S622
SET COMMUNICATION VOLTAGE TO V2
DETERMINE THAT LENS IS NOT ATTACHED, AND PERFORM NO LENS COMMUNICATION
STOP OF CAMERA
S612
EXECUTION OF INITIAL COMMUNICATION (ACQUIRE LENS ID)
S631
NO
DOES LENS NEED RESET?
YES
S632
COMMUNICATION PROCESSING FOR RESET
1
S660
DOES IMAGING INTERRUPTION OCCUR?
NO
YES
S661
ACQUISITION OF FIRST OPTICAL PARAMETER
S662
IS INTERCHANGEABLE LENS THE LENS TYPE 2?
NO
YES
S663
ACQUISITION OF SECOND OPTICAL PARAMETER
S664
NO
IS POWER-OFF REQUESTED?
YES
TURN OFF POWER SOURCE
S665
NO
IS VOLTAGE OF MIF_IN TERMINAL IN HIGH LEVEL?
YES
S666
STOP OF COMMUNICATION WITH LENS
STOP OF CAMERA

FIG.7

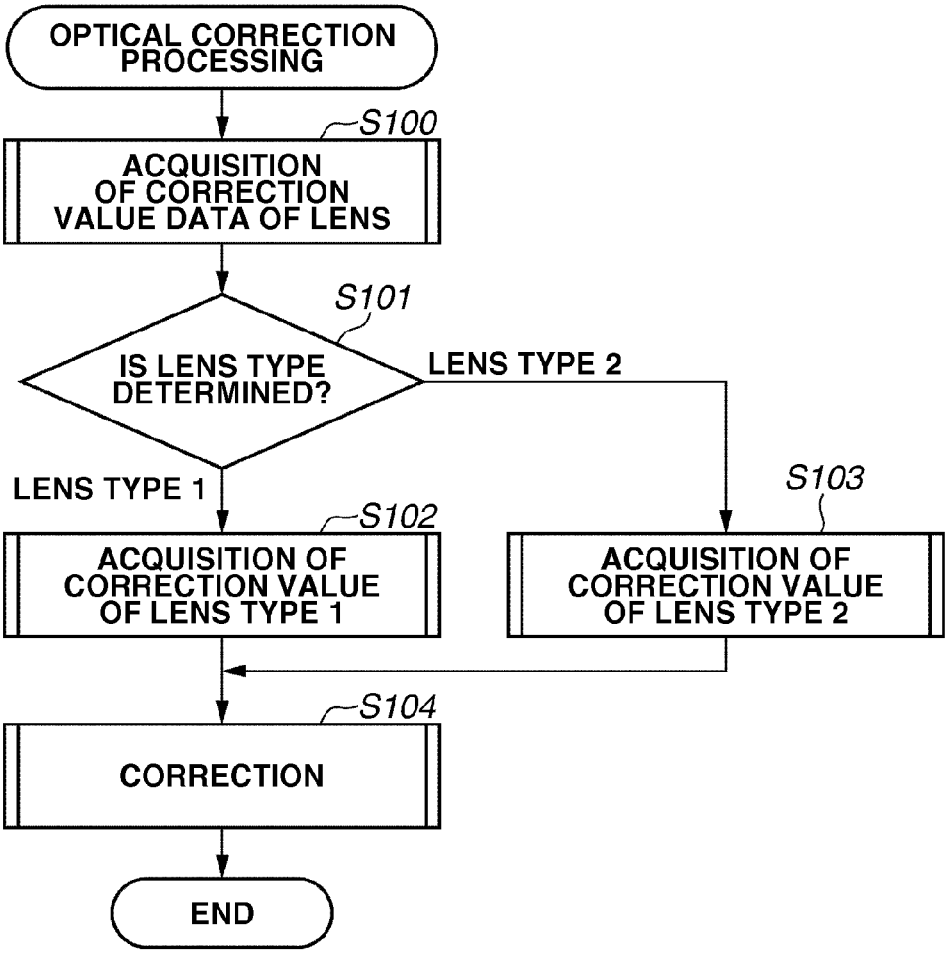

OPTICAL CORRECTION PROCESSING
S100
ACQUISITION OF CORRECTION VALUE DATA OF LENS
S101
IS LENS TYPE DETERMINED?
LENS TYPE 2
LENS TYPE 1
S103
S102
ACQUISITION OF CORRECTION VALUE OF LENS TYPE 1
ACQUISITION OF CORRECTION VALUE OF LENS TYPE 2
S104
CORRECTION
END

FIG.8

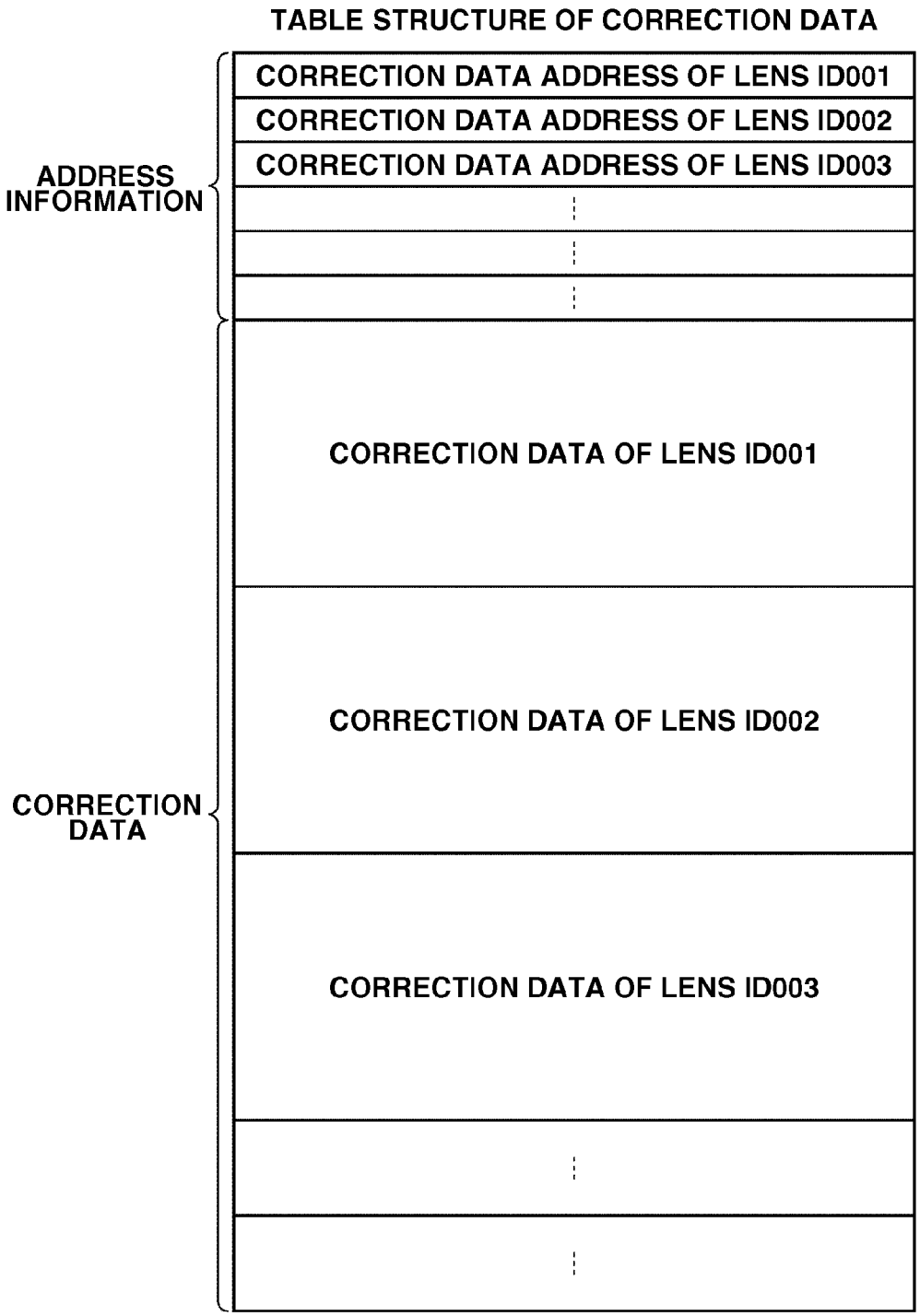


TABLE STRUCTURE OF CORRECTION DATA
ADDRESS INFORMATION
CORRECTION DATA ADDRESS OF LENS ID001
CORRECTION DATA ADDRESS OF LENS ID002
CORRECTION DATA ADDRESS OF LENS ID003
CORRECTION DATA
CORRECTION DATA OF LENS ID001
CORRECTION DATA OF LENS ID002
CORRECTION DATA OF LENS ID003

FIG.9A

CORRECTION DATA STRUCTURE OF LENS TYPE 1

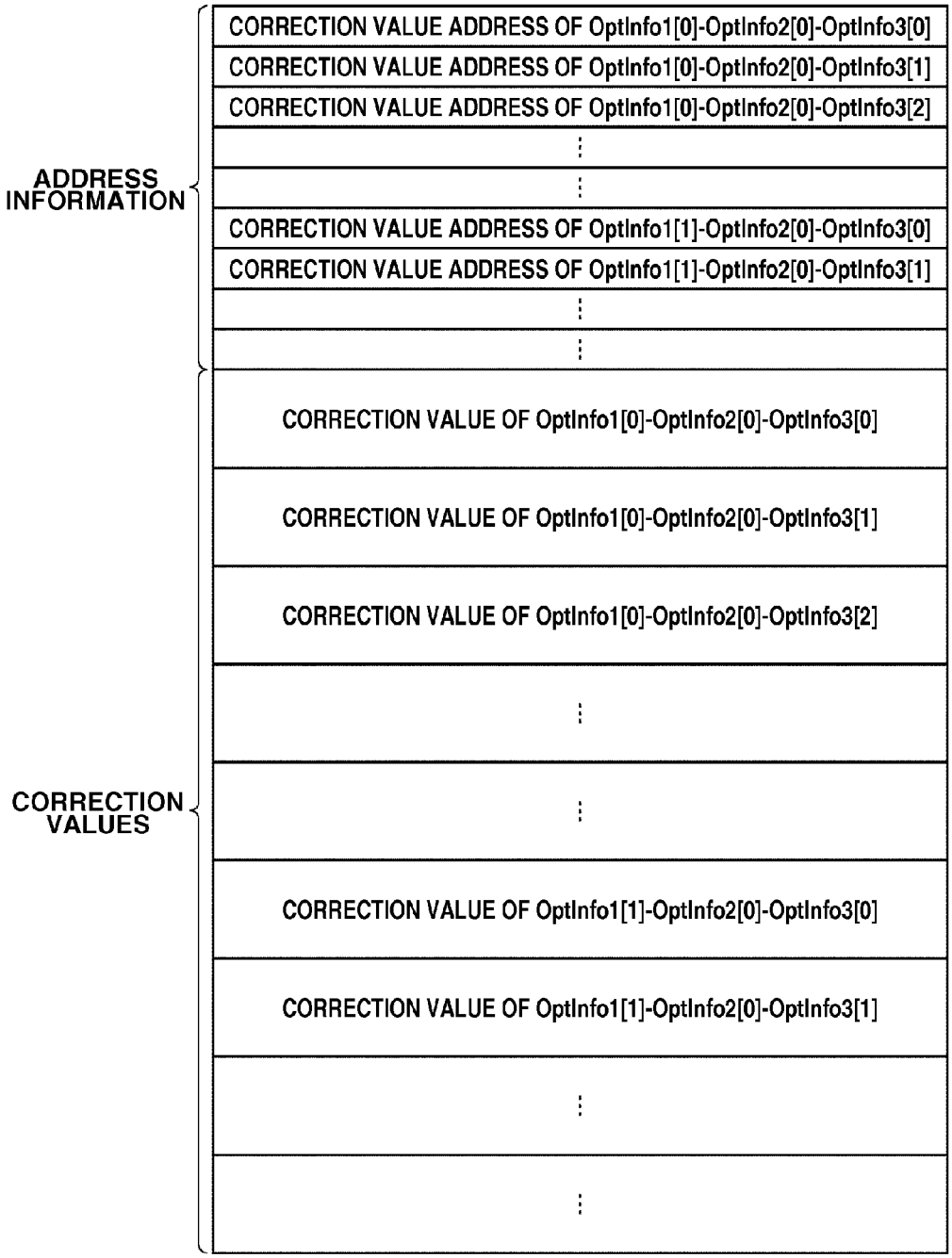


FIG.9B

CORRECTION DATA STRUCTURE OF LENS TYPE 2

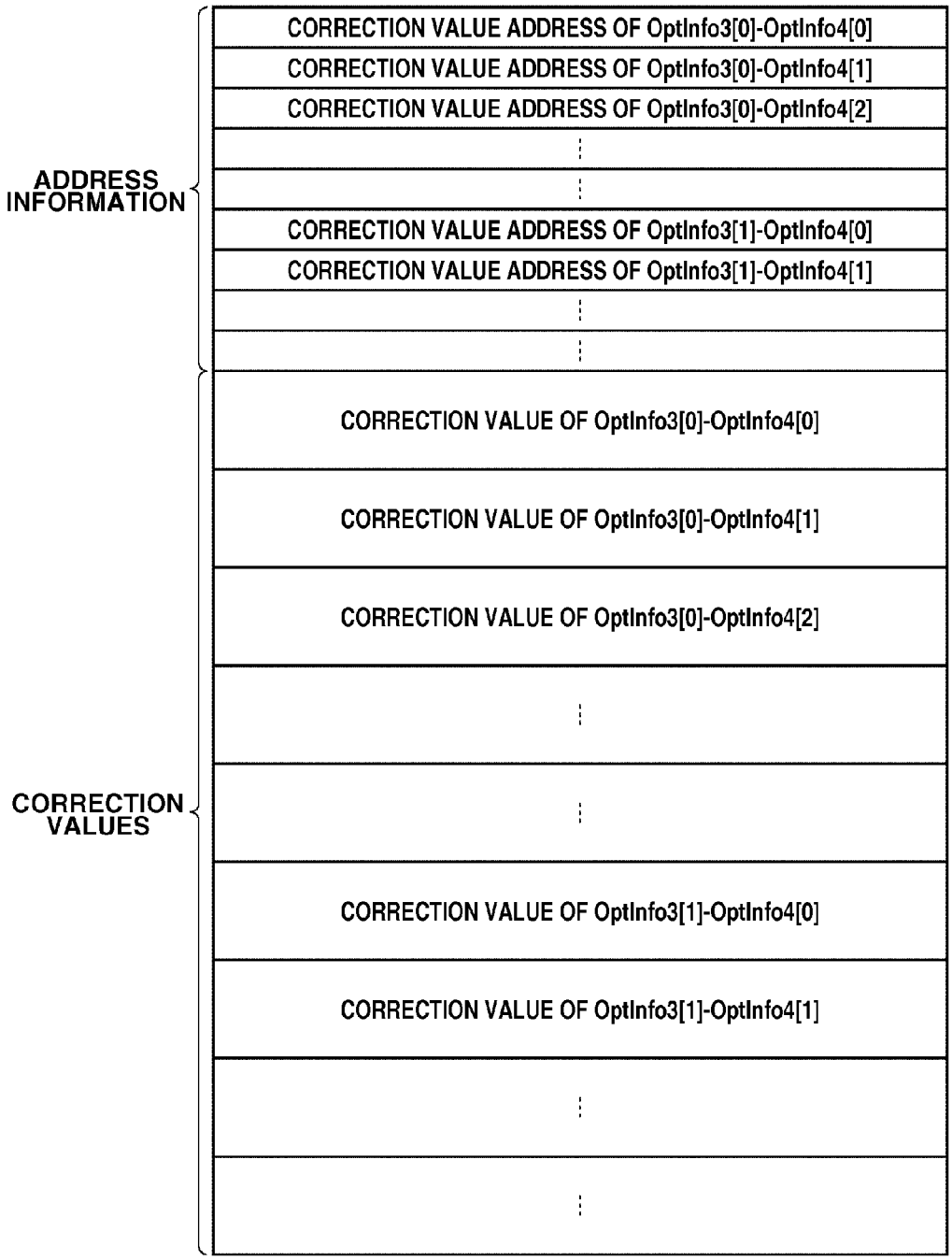


FIG.10

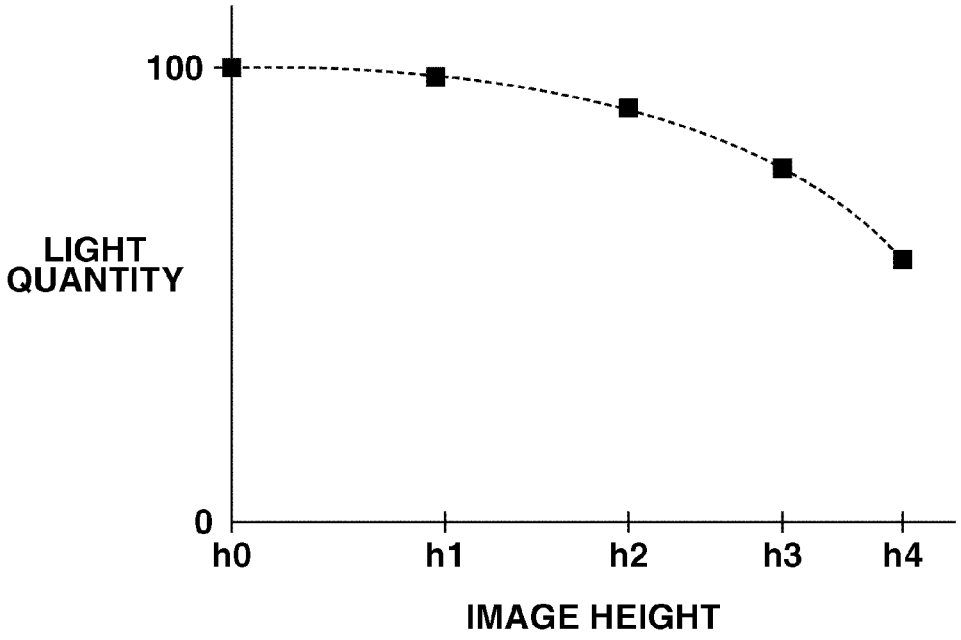


FIG.11A

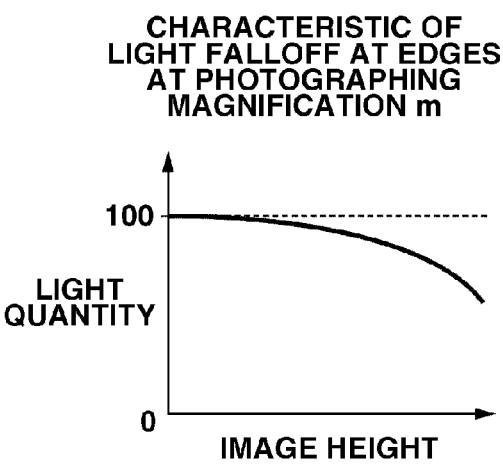


FIG.11B

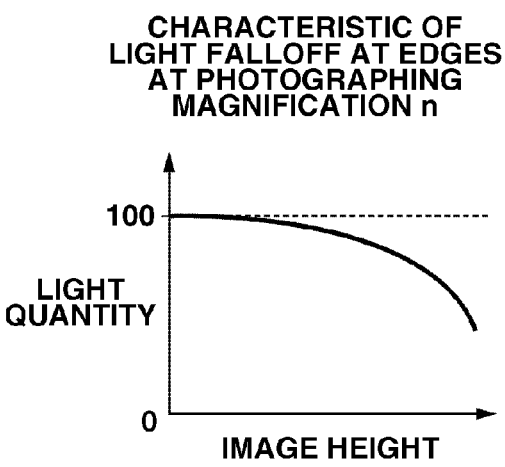


FIG.11C

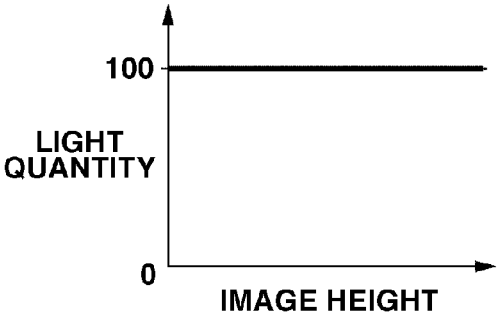


FIG.11D

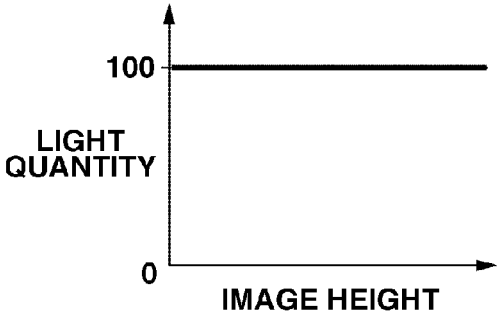


FIG.12

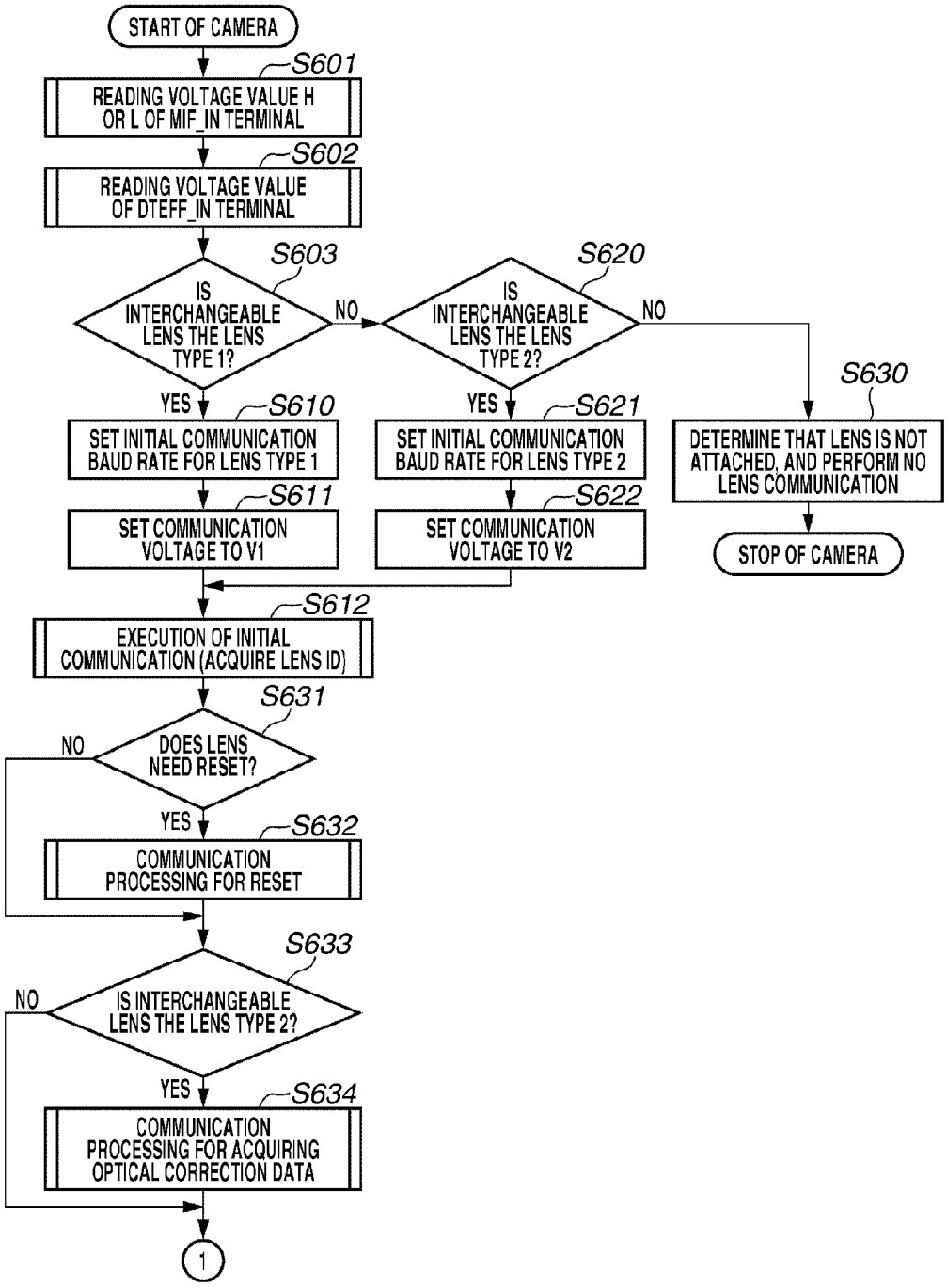
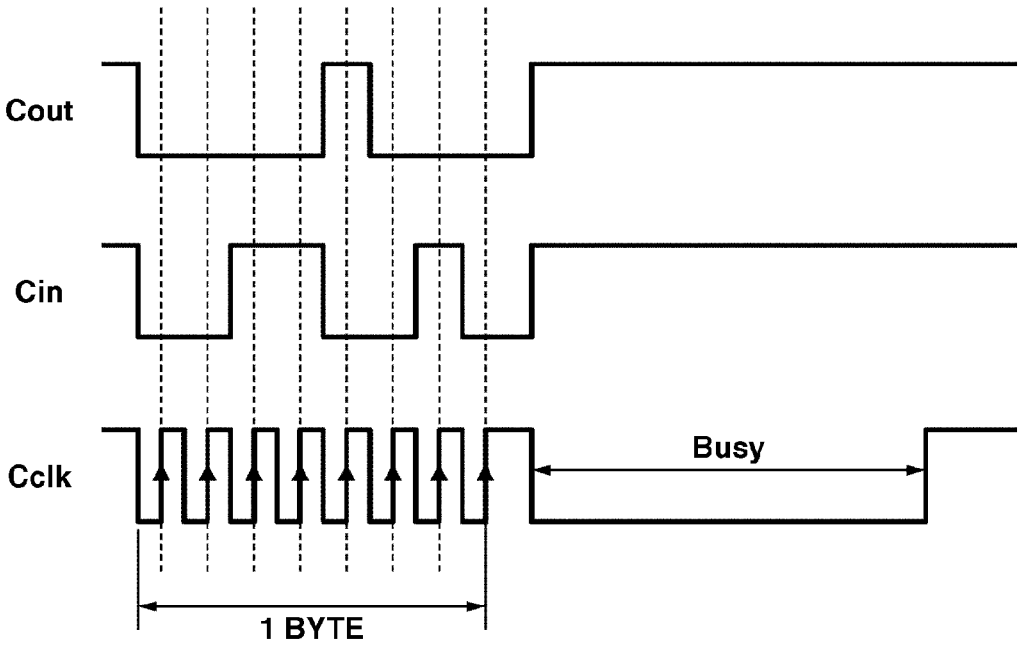

START OF CAMERA
S601
READING VOLTAGE VALUE H OR L OF MIF_IN TERMINAL
S602
READING VOLTAGE VALUE OF DTEFF_IN TERMINAL
S603
IS INTERCHANGEABLE LENS THE LENS TYPE 1?
NO
S620
IS INTERCHANGEABLE LENS THE LENS TYPE 2?
NO
S630
YES
S610
SET INITIAL COMMUNICATION BAUD RATE FOR LENS TYPE 1
S611
SET COMMUNICATION VOLTAGE TO V1
YES
S621
SET INITIAL COMMUNICATION BAUD RATE FOR LENS TYPE 2
S622
SET COMMUNICATION VOLTAGE TO V2
DETERMINE THAT LENS IS NOT ATTACHED, AND PERFORM NO LENS COMMUNICATION
STOP OF CAMERA
S612
EXECUTION OF INITIAL COMMUNICATION (ACQUIRE LENS ID)
S631
NO
DOES LENS NEED RESET?
YES
S632
COMMUNICATION PROCESSING FOR RESET
S633
NO
IS INTERCHANGEABLE LENS THE LENS TYPE 2?
YES
S634
COMMUNICATION PROCESSING FOR ACQUIRING OPTICAL CORRECTION DATA
1

FIG.13



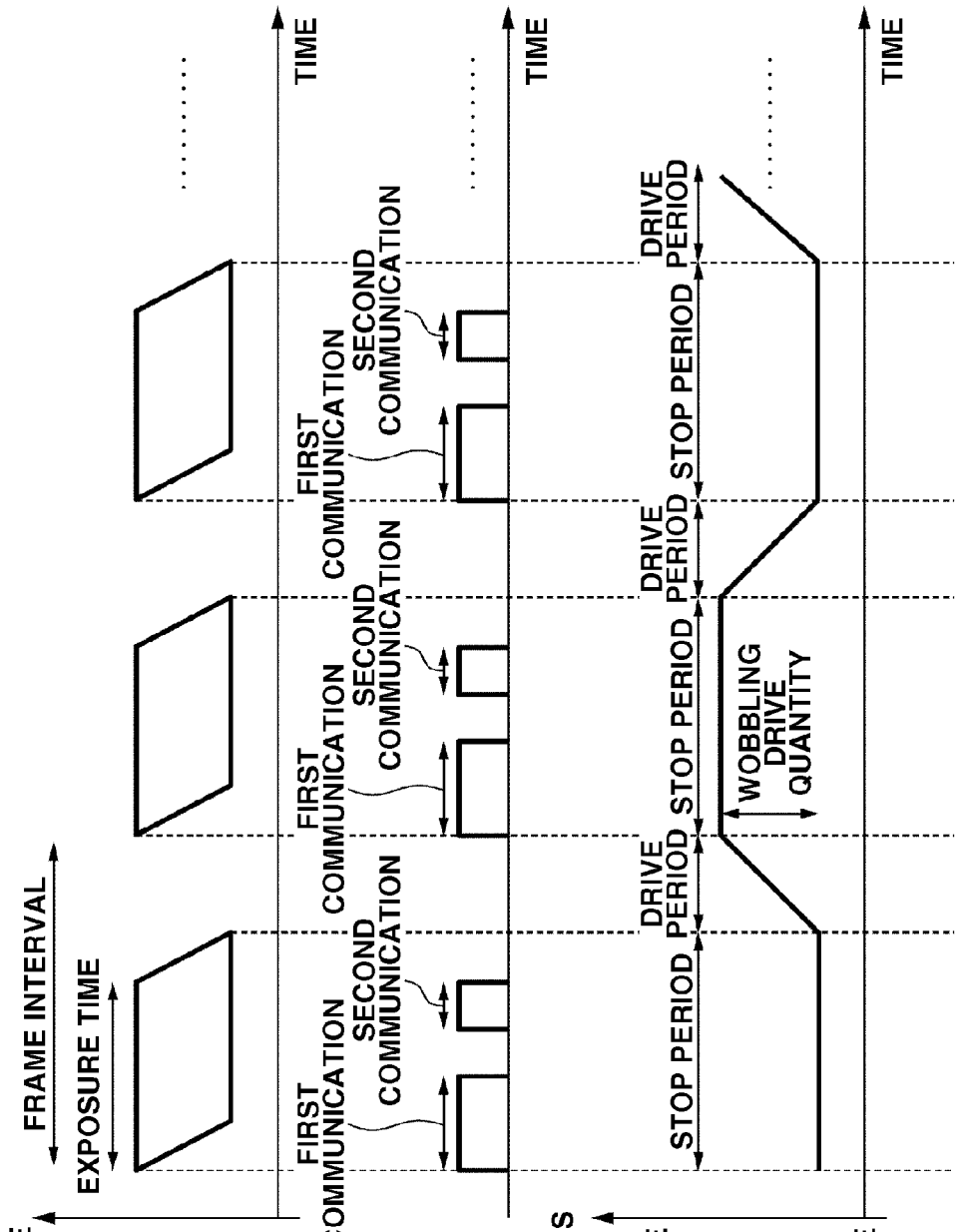

EXPOSURE SECTION
FRAME INTERVAL
EXPOSURE TIME
TIME
EXPOSURE
FIG.14A
FIRST COMMUNICATION
SECOND COMMUNICATION
TIME
LENS COMMUNICATION
FIG.14B
FOCUS LENS POSITION
INFINITE DISTANCE SIDE
CLOSEST DISTANCE SIDE
STOP PERIOD
DRIVE PERIOD
WOBBLING DRIVE QUANTITY
TIME
LENS DRIVE
FIG.14C

FIG.15

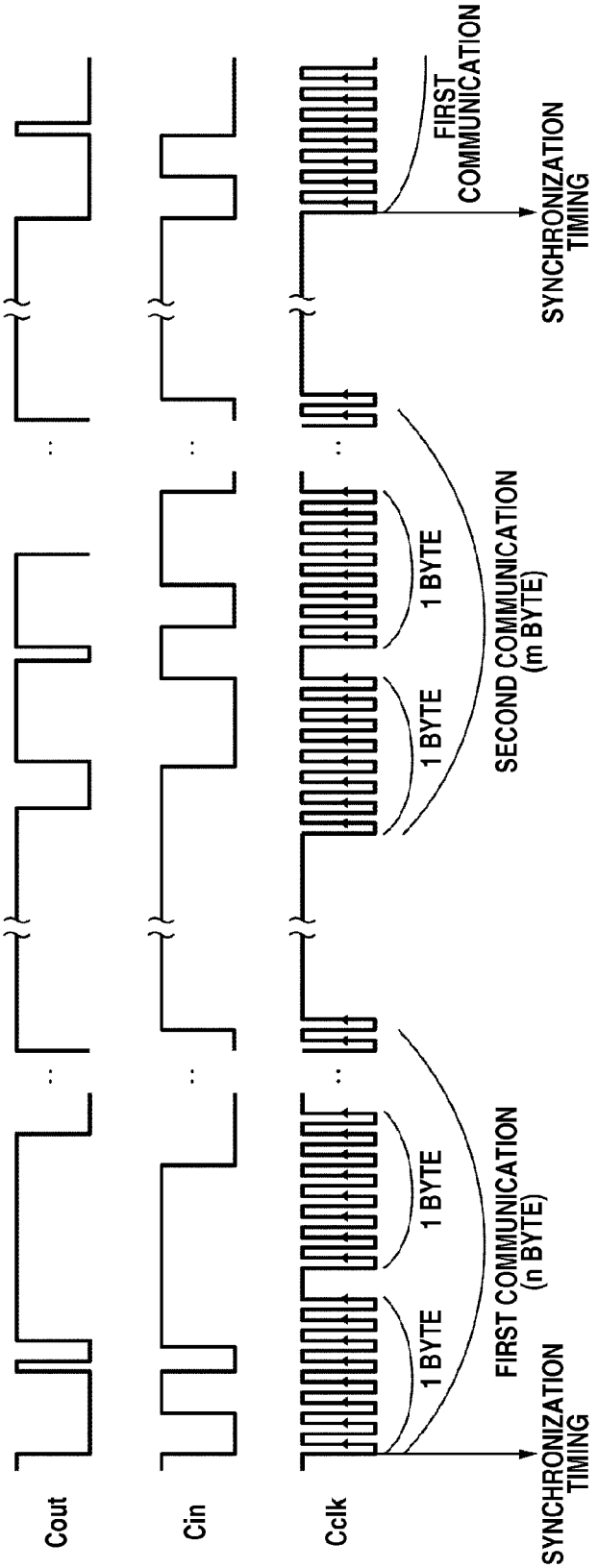

Cout
Cin
Cclk
1 BYTE
1 BYTE
FIRST COMMUNICATION (n BYTE)
SYNCHRONIZATION TIMING
1 BYTE
1 BYTE
SECOND COMMUNICATION (m BYTE)
FIRST COMMUNICATION
SYNCHRONIZATION TIMING

FIG.16

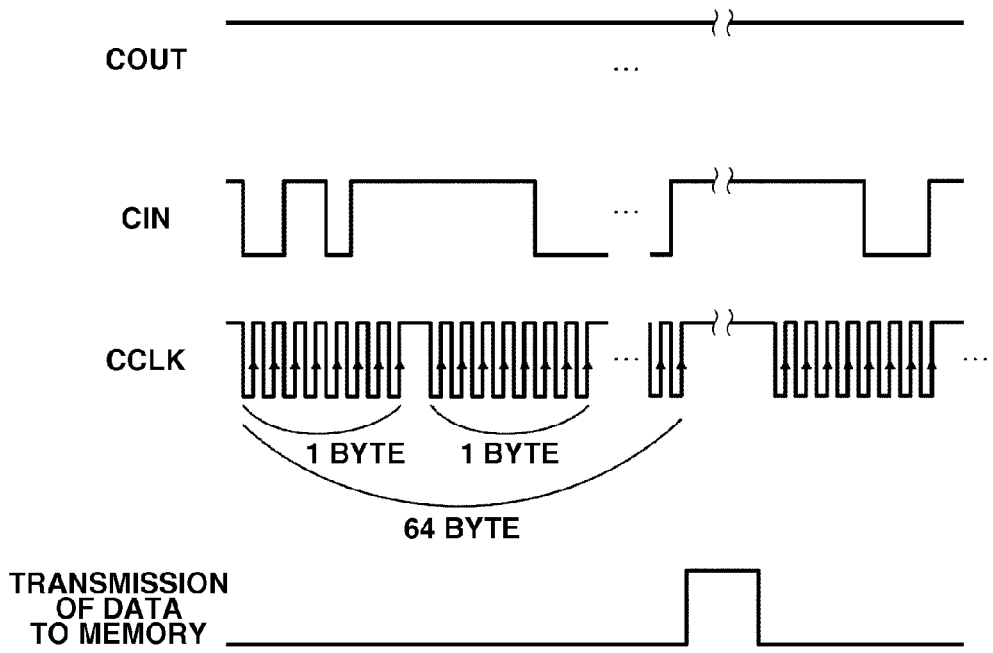

COUT
CIN
CCLK
1 BYTE
1 BYTE
64 BYTE
TRANSMISSION OF DATA TO MEMORY

FIG.17A

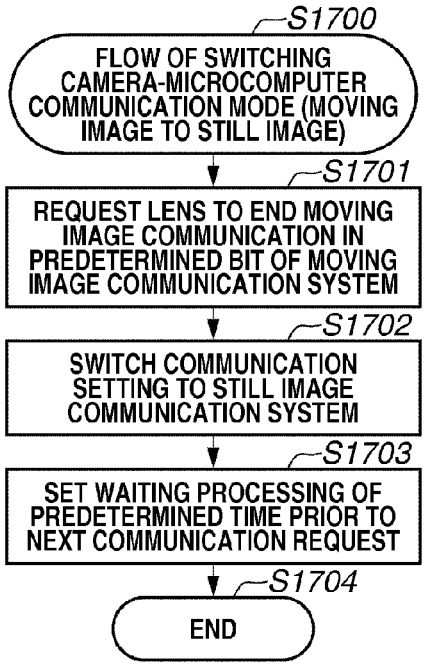


FIG.17B

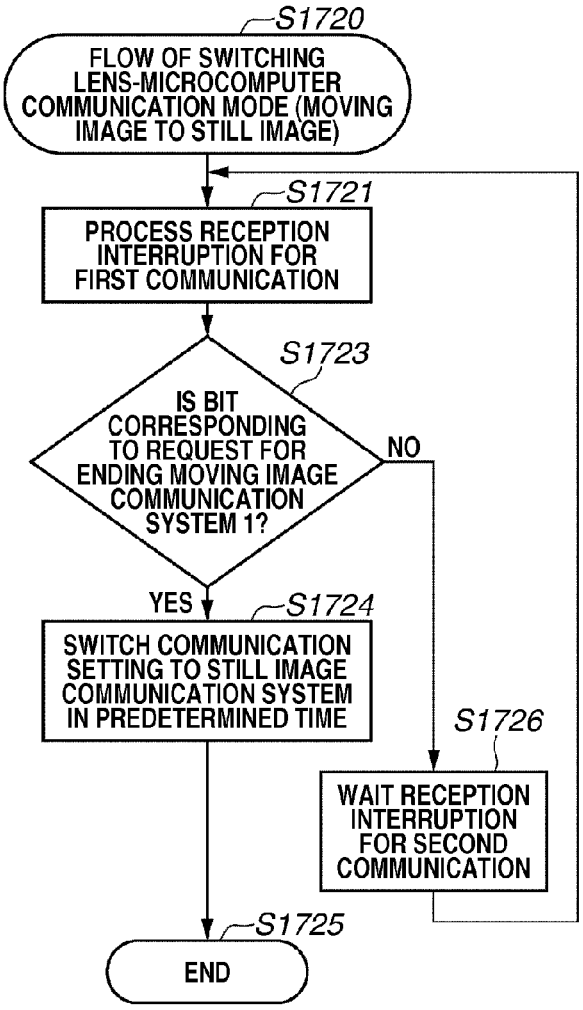


FIG.18A

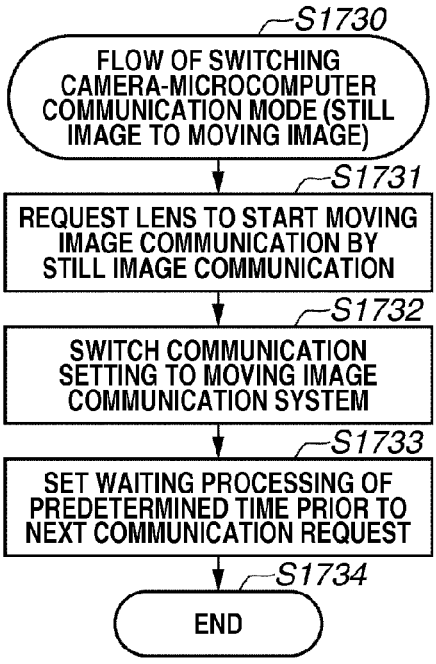


FIG.18B

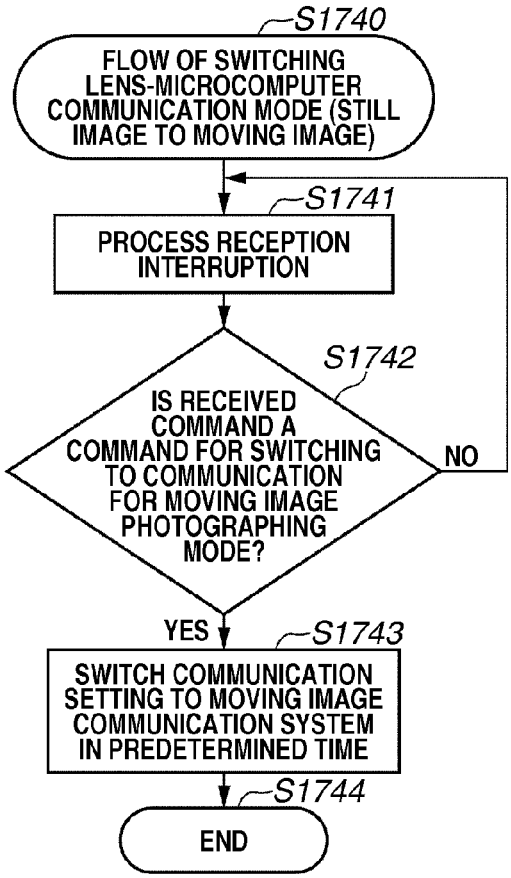


FIG.19

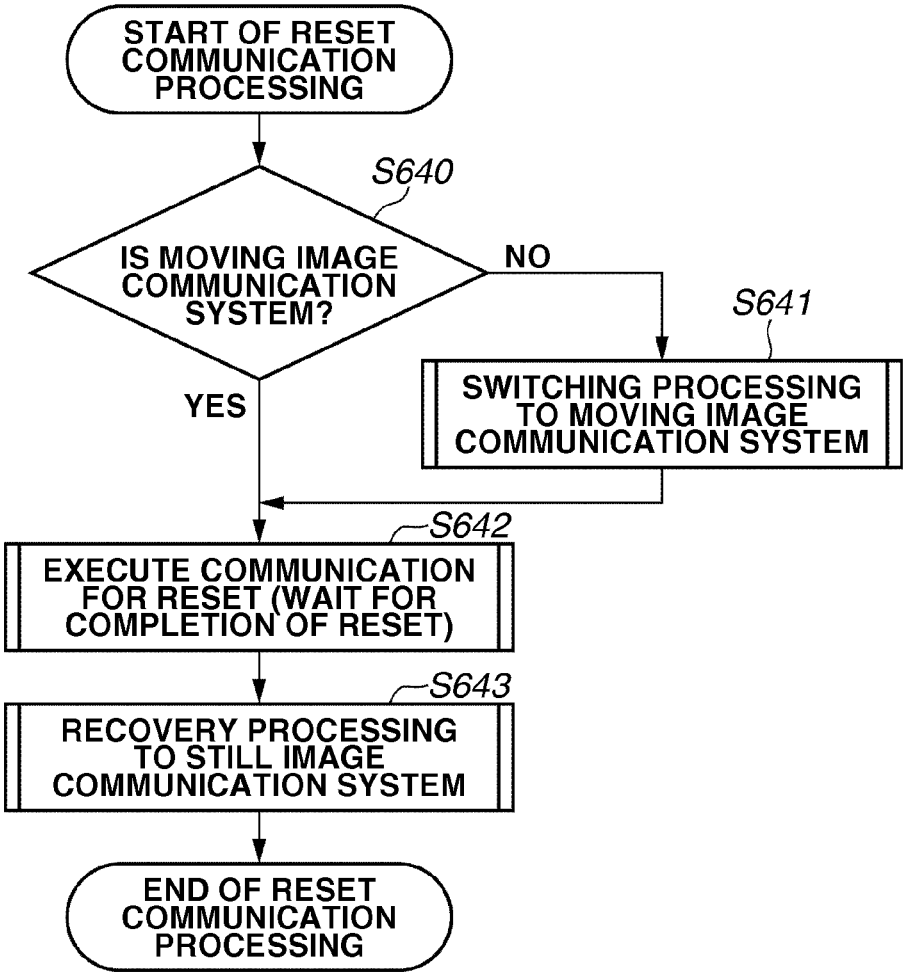
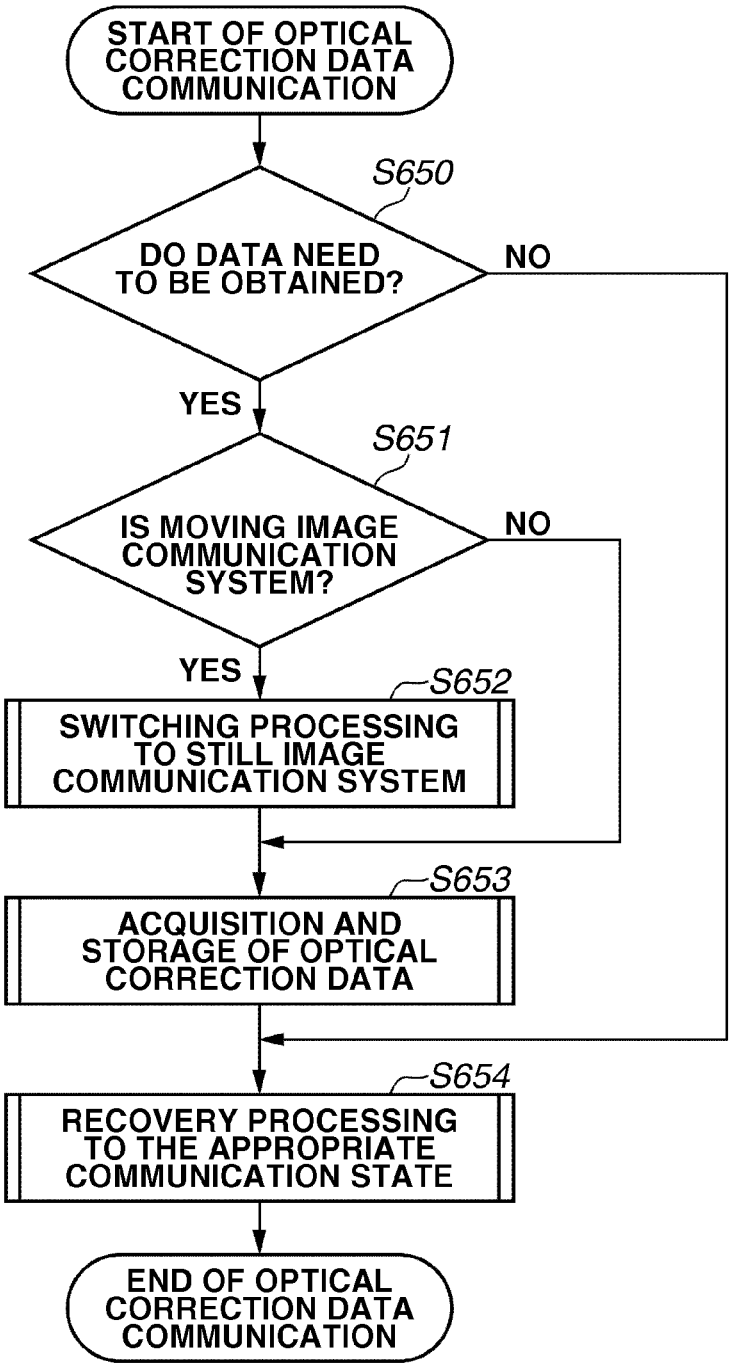

START OF RESET COMMUNICATION PROCESSING
S640
IS MOVING IMAGE COMMUNICATION SYSTEM?
NO
YES
S641
SWITCHING PROCESSING TO MOVING IMAGE COMMUNICATION SYSTEM
S642
EXECUTE COMMUNICATION FOR RESET (WAIT FOR COMPLETION OF RESET)
S643
RECOVERY PROCESSING TO STILL IMAGE COMMUNICATION SYSTEM
END OF RESET COMMUNICATION PROCESSING

FIG.20


START OF OPTICAL CORRECTION DATA COMMUNICATION
S650
DO DATA NEED TO BE OBTAINED?
NO
YES
S651
IS MOVING IMAGE COMMUNICATION SYSTEM?
NO
YES
S652
SWITCHING PROCESSING TO STILL IMAGE COMMUNICATION SYSTEM
S653
ACQUISITION AND STORAGE OF OPTICAL CORRECTION DATA
S654
RECOVERY PROCESSING TO THE APPROPRIATE COMMUNICATION STATE
END OF OPTICAL CORRECTION DATA COMMUNICATION

IMAGING APPARATUS AND METHOD FOR CONTROLLING THE SAME, AND LENS UNIT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an imaging apparatus with an interchangeable lens unit and a method for controlling the same, and, in particular, to a communication system optimum for each type of a lens unit to be attached and each function of the lens unit, and to a technique whereby to correct image degradation resulting from optical characteristics of the lens unit.

The present invention also relates to a communication processing between a camera and a lens unit suited for correction of image degradation resulting from optical characteristics of the lens unit, and to the lens unit.

2. Description of the Related Art

An imaging apparatus such as a digital camera and a digital video camera is always required to have a high-quality output image. This also holds true of the digital camera and the digital video camera which are provided with an interchangeable lens unit.

Along with that, a control technique for the lens unit has been more and more complicated. For example, an initial positioning for a focus mechanism and a diaphragm mechanism, which form the lens unit, is made to perform high-accuracy control. Also as an example, there is a mechanism for correcting an optical characteristic, which is one of factors degrading image quality, of the lens unit used for capturing an object image. A light falloff at edges, distortion aberration, and chromatic aberration of magnification are cited as examples of the optical characteristic causing image degradation. It is difficult to realize a lens unit completely eliminating the above factors. For this reason, a technique is known in which a captured image is subjected to image processing to correct image degradation caused by the optical characteristic (an optical correction technique).

Even the same lens unit changes in its optical characteristic depending on values of optical parameters, such as a focal length (angle of view of a zoom lens), a photographing distance (a focusing distance) and an aperture value. Therefore, if the image degradation caused by the optical characteristic is corrected by the image processing, an optical correction value corresponding to the optical parameter in capturing an image needs to be used to accurately correct the image degradation.

Japanese Patent Application Laid-Open No. 2005-286482 discusses a method for determining an optical correction quantity based on a polynomial approximate equation obtained from transition of a distortion correction quantity according to a zoom position of the zoom lens (focal length).

A conventional technique discussed in Japanese Patent Application Laid-Open No. 2005-286482 does not consider what type of communication system is used for switching to perform an appropriate communication between a camera and a lens.

SUMMARY OF THE INVENTION

According to an aspect of the present invention, an imaging apparatus, to which a lens unit with an optical member is attached and which communicates with the lens unit to transmit a control signal for the optical member, includes a communication unit configured to communicate with the attached lens unit, an imaging unit configured to be able to capture an object image formed by the optical member of the attached lens unit, a lens information acquisition unit configured to acquire individual information of the attached lens unit, a determination unit configured to determine a communication system with the lens unit, and a reset instruction unit configured to instruct the lens unit to reset the optical member thereof, wherein a first communication system is used for communication for acquiring the individual information of the lens unit by the lens information acquisition unit, and a second communication system different from the first communication system is used for communication for instructing the lens unit to reset the optical member by the reset instruction unit.

According to another aspect of the present invention, a lens unit exposing an object image on an imaging apparatus including an imaging unit capable of capturing the object image includes an optical member capable of being driven, a communication unit configured to communicate with the imaging apparatus, to which the lens unit is attached, a memory configured to store individual information, a setting unit configured to set a communication system with the imaging apparatus, and a reset unit configured to reset the optical member in response to an instruction from the imaging apparatus, to which the lens unit is attached, wherein a first communication system is used when the individual information of the lens unit is transmitted to the imaging apparatus, to which the lens unit is attached, and a second communication system different from the first communication system is used for subsequently receiving an instruction of the reset operation of the lens unit.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating an example of a functional configuration of an interchangeable lens digital video camera system as an example of an imaging apparatus according to a first exemplary embodiment of the present invention.

FIG. **2** illustrates an example of a relation between magnification and a photographing distance of a single focus macro lens.

FIGS. **3**A, **3**B, **3**C, and **3**D illustrate characteristics of light falloff at edges of the macro lens with the characteristic illustrated in FIG. **2**, and examples of results of correcting the light falloff at edges using an optical correction value obtained from the photographing distance illustrated in FIG. **2**.

FIG. **4** is a block diagram illustrating an example of configuration according to communication between a camera control unit and a lens control unit.

FIGS. **5**A and **5**B illustrate examples of configuration of a lens-type determination unit of the lens control unit in FIG. **4**.

FIG. **6** is a flow chart illustrating processing for determining the type of an interchangeable lens, a communication control method for each lens type, and processing for receiving an optical parameter which are performed by the camera control unit according to the first exemplary embodiment of the present invention.

FIG. **7** is a flow chart illustrating optical correction processing according to the first exemplary embodiment of the present invention.

FIG. **8** illustrates an example of a structure of optical correction data stored in the memory **106** in FIG. **1**.

FIG. **9**A illustrates an example of a structure of optical correction data stored in the memory **106** in FIG. **1**.

FIG. **9**B illustrates an example of a structure of optical correction data stored in the memory **106** in FIG. **1**.

FIG. **10** illustrates an example of an optical correction value stored for each of combinations of the optical parameters.

FIGS. **11**A, **11**B, **11**C, and **11**D illustrate characteristics of light falloff at edges of the macro lens with the characteristic illustrated in FIG. **2**, and examples of results of correcting the light falloff at edges using the optical correction value obtained from the present exemplary embodiment.

FIG. **12** is a flow chart illustrating processing for determining the type of an interchangeable lens, a communication control method for each lens type, and processing for receiving an optical parameter which are performed by a camera control unit according to a second exemplary embodiment of the present invention.

FIG. **13** is a timing chart illustrating a communication system of initial communication in attaching the first interchangeable lens according to the exemplary embodiment of the present invention.

FIGS. **14**A, **14**B, and **14**C illustrate communication systems synchronized with an imaging timing signal according to the exemplary embodiment of the present invention.

FIG. **15** illustrates a first and a second communication synchronized with the imaging timing signal according to the exemplary embodiment of the present invention.

FIG. **16** illustrates methods for acquiring optical correction data according to the second exemplary embodiment of the present invention by communication and storing the data in the camera.

FIGS. **17**A and **17**B are flow charts illustrating processing of the camera and the lens at the time of switching the communication systems synchronized with the imaging timing signal and not synchronized with the imaging timing signal according to the exemplary embodiment of the present invention.

FIGS. **18**A and **18**B are flow charts illustrating processing for switching from a still image communication system to a moving image communication.

FIG. **19** is a flow chart illustrating reset communication processing.

FIG. **20** is a flow chart illustrating optical correction data communication.

DESCRIPTION OF THE EMBODIMENTS

FIG. **1** illustrates a block diagram of an example of a functional configuration of an interchangeable-lens digital video camera system as an example of an imaging apparatus according to a first exemplary embodiment of the present invention. The camera system includes a camera **10** and an interchangeable lens **100** being a lens unit detachable from the camera **10**. Amount **1** is a mechanism for attaching or detaching the interchangeable lens **100** to or from the camera **10**, and includes an electrical contact for supplying power from the camera **10** to the interchangeable lens **100** and for performing communication between the camera **10** and the interchangeable lens **100**. The mount **1** is divided into a part included in the camera **10** and a part included in the interchangeable lens **100**. For the sake of convenience, however, the parts are illustrated an one component in FIG. **1**.

An image sensor **11** is a photoelectric conversion device with a plurality of pixels. The image sensor **11** causes each pixel to photo-electrically convert an object image formed by an imaging lens **101** in the interchangeable lens **100**, and outputs an analog electric signal corresponding to the object image. The image sensor **11** is configured to enable capturing the object image. An analog-to-digital (A/D) conversion unit **12** converts an analog signal output by the image sensor **11** into a digital signal. An image processing unit **13** applies various types of image processing to the digital signal output by the A/D conversion unit **12** to generate image data. The image processing unit **13** includes an optical correction unit **130** providing an optical correction function to correct image degradation due to the optical characteristic of the imaging lens **101** by the image processing, and an other image processing unit **131** that performs image processing such as pixel interpolation processing, luminance signal processing, and color signal processing. The image data generated by the image processing unit **13** is displayed on a display unit **14** and recorded in a recording medium **15** such as a memory card.

A memory **16** is used as a process buffer of the image processing unit **13** and a storage device of a program executed by a camera control unit **18** described below. The memory **16** is also used as a storage device for a below-mentioned optical correction data, on which an optical correction value used by the optical correction unit **130** is defined, and as a storage device for graphic user interface (GUI) data, such as a menu screen, which the camera **10** displays on the display unit **14**.

An operation input unit **17** is an input-device group for a user inputting instructions to the camera, such as a power switch for turning on/off a power source, an imaging switch for starting to record an image, and a selection/setting switch for setting various menus. A camera control unit **18** includes a microcomputer, executes the program stored in the memory **16**, and performs the operation control of the entire camera system, such as control of the image processing unit **13** and communication control with the interchangeable lens **100**.

A lens drive unit **102** of the interchangeable lens **100** drives an actuator and a motor of the imaging lens **101** according to control of a lens control unit **103**. The actuator and the motor of the imaging lens **101** move and operate a focus lens, a zoom lens, a diaphragm, and an image stabilization lens of the imaging lens **101**. The lens control unit **103** includes a microcomputer, and controls the lens drive unit **102** according to a control signal received from the camera control unit **18** via the mount **1**. A memory **104** is used as a storage device for various data used by the lens control unit **103**.

FIG. **4** is a block diagram illustrating an example of configuration according to communication between the camera control unit **18** and the lens control unit **103**.

Terminals of the mount **1** are described below.

An LCLK terminal **1-1** is a terminal used for a communication clock signal output from the camera **10** to the interchangeable lens **100**. A DCL terminal **1-2** is a terminal used for communication data output from the camera **10** to the interchangeable lens **100**. A DCL terminal **1-3** is a terminal used for communication data output from the interchangeable lens **100** to the camera **10**.

An MIF terminal **1-4** is a terminal for detecting that the interchangeable lens **100** is attached to the camera **10**. The microcomputer **20** in the camera control unit **18** (hereinafter, referred to as a camera microcomputer) detects that the interchangeable lens **100** is attached to the camera **10** based on the voltage of the MIF terminal **1-4**.

A DTEF terminal **1-5** is a terminal for detecting the type of the interchangeable lens **100** attached to the camera **10**.

The camera microcomputer **20** detects the type of the interchangeable lens **100** attached to the camera **10** based on the voltage of the DTEF terminal **1-5**.

A VBAT terminal **1-6** is a terminal for supplying a drive power source (VM) used for various operations excluding communication control to the interchangeable lens **100** from the camera **10**. A VDD terminal **1-7** is a terminal for supplying a communication control power source (VDD) used for communication control to the interchangeable lens **100** from the camera **10**. A DGND terminal **1-8** is a terminal for connecting a communication control system of the camera **10** and the interchangeable lens **100** to the ground. A PGND terminal **1-9** is a terminal for connecting a mechanical drive system including an actuator and a motor provided on the camera **10** and the interchangeable lens **100** to the ground.

A plurality of types of the interchangeable lenses **100** which are different in voltage for communication with the camera **10** can be connected to the camera **10** of the present exemplary embodiment. In the following description, for the sake of simplifying description and facilitating understanding, there are two types of the interchangeable lenses **100** which the camera **10** identifies based on the voltage of the DTEF terminal **1-5**: a first interchangeable lens (a first lens unit); and a second interchangeable lens (a second lens unit) different in voltage for communication with the first lens unit.

The "type" detected by the voltage of the DTEF terminal **1-5** is the one that is classified according to the "type" of an optical parameter required for identifying the optical correction value, and does not always correspond to a "model." The "type" of the interchangeable lens previously associated with the "type" of the optical parameter required for identifying the optical correction value may be stored in the memory **16**, for example.

In the present exemplary embodiment, the first interchangeable lens is the one that the optical parameter required for identifying the optical correction value is information from which each of a focal length (units in mm), a photographing distance (units in cm), and an aperture value can be identified. The information from which the focal length can be identified is a value of a focal length and a position of a zoom lens, for example. The information from which the photographing distance can be identified is a value of a photographing distance and a position of a focus lens, for example. The information from which the aperture value can be identified is an aperture value and a value corresponding to the aperture value, for example.

The second interchangeable lens is the one that the optical parameter required for identifying the optical correction value is information from which each of an aperture value and a photographing magnification can be identified. The information from which the photographing magnification can be identified is a value of a photographing magnification and positional information about an optical member for controlling the photographing magnification, for example. A macro lens is an example of the interchangeable lens corresponding to the second interchangeable lens. The photographing magnification of the macro lens is changed by the optical member whose position is changed by the rotation of a magnification change ring. For this reason, the photographing magnification may be used as identifiable information, and positional information about a photographing magnification changing mechanism such as the magnification change ring may be used as positional information about the optical member for controlling the photographing magnification.

A camera power source unit **21** provided in the camera control unit **18** converts a battery voltage supplied from the battery mounted on the camera **10** into voltage required for the operation of each unit. In the present exemplary embodiment, the camera power source unit **21** generates voltages V**1**, V**2**, V**3**, and VM.

A first voltage V**1** is a power source voltage as a communication control power source (VDD) for the first and second interchangeable lenses and a communication voltage for the first interchangeable lens. A second voltage V**2** is a communication voltage for the second interchangeable lens. A third voltage V**3** is a power source voltage used as a power source for operating the camera microcomputer **20**. A fourth voltage V**4** is a power source voltage used as a power source for driving the first and second interchangeable lenses.

When power is turned on by the operation of the power switch of the operation input unit **17**, the camera microcomputer **20** outputs a signal for turning on a switch **22** from a CNT_VDD_OUT terminal and the camera **10** starts to supply the VDD and the VM to the interchangeable lens **100**. When the camera microcomputer **20** is instructed to turn off the power, the camera microcomputer **20** stops outputting the signal from the CNT_VDD_OUT terminal to turn off the switch **22**, so that the camera **10** stops supplying the VDD and the VM to the interchangeable lens **100**.

The camera microcomputer **20** communicates with the interchangeable lens **100** via a voltage conversion unit **23**. The camera microcomputer **20** includes an LCLK_OUT terminal for outputting a communication clock signal, a DCL_OUT terminal for outputting communication data to the interchangeable lens, and a DLC_IN terminal for receiving communication data from the interchangeable lens. The communication clock signal and the communication data are signals for communication.

The camera microcomputer **20** further includes an MIF_IN terminal for detecting whether the interchangeable lens **100** is attached, a DTEF_IN terminal for identifying the type of the interchangeable lens **100**, and a CNT_V_OUT terminal for outputting a communication voltage switching signal to the voltage conversion unit **23**.

The camera microcomputer **20** still further includes the CNT_VDD_OUT terminal for outputting a signal for turning on and off the switch **22**, a terminal for connecting the camera microcomputer **20** with the image processing unit **13**, and a terminal for connecting the camera microcomputer **20** with the operation input unit **17**.

The microcomputer **211** in the lens control unit **103** (hereinafter, referred to as a lens microcomputer) communicates with the camera microcomputer **20** via the voltage conversion unit **23** of the camera control unit **18**. The lens microcomputer **211** includes an LCLK_IN terminal for receiving a communication clock signal, a DLC_OUT terminal for outputting communication data to the camera **10**, a DCL_IN terminal for receiving communication data from the camera **10**, and a terminal for connecting the lens microcomputer **211** with the lens drive unit **102**. The lens control unit **103** includes a lens power source unit **214** for generating a voltage for operating the lens microcomputer **211** from the VDD.

The following describes a method for detecting whether the interchangeable lens **100** is attached to the camera **10**. The MIF_IN terminal of the camera microcomputer **20** is pulled up to the power source by a resistor R**2** (100 KΩ), so that the voltage value of the MIF_IN terminal is at a high level when the interchangeable lens **100** is not attached. However, when the interchangeable lens **100** (the first and second interchangeable lenses) is attached, the MIF_IN

terminal is connected to ground (GND) in the interchangeable lens **100**, so that the voltage value is brought into a low level (L) independently of the type of the interchangeable lens **100**.

FIGS. **5**A and **5**B illustrate examples of configuration of a lens-type determination unit **213** of the lens control unit **103**. The lens-type determination unit **213** includes an accessory-side resistor RL provided between a DTEF terminal provided on the mount **1** and the GND. The value of the resistor RL is previously set according to the type of the interchangeable lens **100**. The resistor RL provided on the first interchangeable lens illustrated in FIG. **5**A is set to 0Ω and the resistor RL provided on the second interchangeable lens illustrated in FIG. **5**B is set to 300Ω, for example.

In the camera **10**, a camera-side resistor R**1** (100 KΩ, for example) is connected between the DTEF terminal of the mount **1** and the voltage (V**3**) of an operation power source of the camera microcomputer **20**, and the DTEF terminal is connected to the DTEF_IN terminal of the camera microcomputer **20**. The DTEF_IN terminal of the camera microcomputer **20** has an analog-to-digital (AD) conversion function (a 10-bit AD conversion function with 0 to 1.0 V as an input range).

The following describes how the camera microcomputer **20** determines the type of the interchangeable lens **100**. The camera microcomputer **20** determines the type of the attached interchangeable lens **100** according to a voltage value to be input to the DTEF_IN terminal. More specifically, the camera microcomputer **20** performs analog-to-digital (AD) conversion on the input voltage value and, compares the AD conversion value with a lens-type determination reference previously stored in the camera microcomputer **20** to determine the type of the lens.

When the first interchangeable lens is attached, the AD conversion value of the voltage input to the DTEF_IN terminal is determined to be about "0x0000" by a resistance ratio of RL/(R**1**+RL), where the R**1** is 100 KΩ and the RL is 0Ω. For this reason, the camera microcomputer **20** determines that the AD conversion value of the DTEF_IN terminal falls within the range of "0x0000 to 0x007F", which is the first lens type determination reference, to determine that the attached interchangeable lens is the first interchangeable lens.

When the second interchangeable lens is attached, the AD conversion value of the voltage input to the DTEF_IN terminal is determined to be about "0x02FF" by a resistance ratio of RL/(R**1**+RL), where the R**1** is 100 KΩ and the RL is 300 KΩ. For this reason, the camera microcomputer **20** determines that the AD conversion value of the DTEF_IN terminal falls within the range of "0x0280 to 0x037F", which is the second lens type determination reference, to determine that the attached interchangeable lens is the second interchangeable lens.

As described above, the camera microcomputer **20** determines the type of the attached interchangeable lens **100** based on the voltage value input to the DTEF_IN terminal. The camera microcomputer **20** controls the logic level of the signal output from the CNT_V_OUT terminal according to the determination result of the type of the interchangeable lens **100**. Specifically, if the camera microcomputer **20** determines that the attached interchangeable lens **100** is the first interchangeable lens from the voltage value of the DTEF_IN terminal, the camera microcomputer **20** outputs a high-level (H-level) signal from the CNT_V_OUT terminal and sets a communication voltage to V**1**. If the camera microcomputer **20** determines that the attached interchangeable lens **100** is the second interchangeable lens, the camera microcomputer **20** outputs a low-level (L-level) signal from the CNT_V_OUT terminal and sets the communication voltage to V**2**.

The camera microcomputer **20** determines the frequency of a clock output from the LCLK terminal according to the determination result of the type of the attached interchangeable lens **100**. Since a comparatively old lens, for example, tends to correspond only to communication at a low frequency, such an old lens is determined as the first interchangeable lens and initial communication is started at a low frequency. If the camera microcomputer **20** determines that the attached interchangeable lens **100** is the second interchangeable lens, initial communication is started at a high-speed baud rate. This allows the initial communication to be performed for a comparatively new lens at a high-speed baud rate from the initial communication without performing communication once and a transfer of a mutually communicable baud rate, enabling a starting time to be reduced.

FIG. **13** illustrates a synchronous clock system as an example of the initial communication.

Communication terminals Cout, Cin, and Cclk correspond to the DCL, DLC, and LCLK terminals. The camera supplies the Cclk waveform to the lens. Both the camera and the lens transfer data signals to Cin and Cout to synchronize the data signal with the Cclk waveform. There exists a period for which a signal from the communication terminal Cclk is kept at an L-level output over a predetermined time period. The period is the one for which the lens control unit **103** performs a lens-side processing such as drive control of a focus unit. The camera stops transmitting clocks during the period. If the attached lens is the first interchangeable lens, a clock is supplied at a low-speed baud rate. If the attached lens is the second interchangeable lens, a clock is supplied at a high-speed baud rate.

If the camera microcomputer **20** detects a voltage value outside the reference for determining the first and second lenses as the voltage value (AD conversion value) of the DTEF_IN terminal, the camera microcomputer **20** determines that a "non-adaptive lens", which is a lens to which the camera **10** is not adapted, is attached. Alternatively, the camera microcomputer **20** reserves the determination since the type of the lens cannot be normally determined. In both cases, the camera microcomputer **20** does not communicate with the interchangeable lens **100**.

[Necessity of Optical Correction]

Necessity of optical correction is described below. In a stationary-lens imaging apparatus, optical correction values related to combinations of all optical parameter values may be previously obtained. Actually, only discrete combination is stored according to a required storage capacity and the not-stored combinations may be obtained by interpolation. However, it is comparatively easy to ensure correction accuracy.

In an interchangeable-lens imaging apparatus, on the other hand, there are a great number of different types of attachable lens units. Specific lenses such as a macro lens and a shift lens exist among them.

It is also necessary to ensure interchangeability with lens units which are not adapted to a new communication protocol and to perform an appropriate camera-control adapted to the type of the attached lens unit and the functions of the lens unit.

As described above, even in a single interchangeable lens, optical characteristics thereof are different for each combination of a plurality of optical parameters. In a general lens, an optical correction value can be uniquely obtained by a combination of focal length, photographing distance, and

aperture value. However, it is sometimes necessary to obtain other optical parameters to identify the optical correction value due to diversification of the lens unit. The following describes this respect.

FIG. **2** illustrates an example of a relation between magnification and a photographing distance of a single focus macro lens capable of capturing an image at equal magnification to n-times magnification. In the example, the photographing distances have the same value between photographing magnifications m and n. The optical characteristic changes with the photographing magnification, so that the optical correction values are different between the photographing magnifications m and n.

FIGS. **3**A, **3**B, **3**C, and **3**D illustrate characteristics of light falloff at edges of the macro lens with the characteristic illustrated in FIG. **2** and examples of results of correcting the light falloff at edges using the optical correction value obtained from the photographing distance illustrated in FIG. **2**. More specifically, FIGS. **3**A, **3**B, **3**C, and **3**D illustrate how the brightness (light quantity) of the image obtained by imaging an object with a uniform luminance changes according to an image height being a distance from an image center with the brightness of the image center as 100.

FIGS. **3**A and **3**B illustrate the characteristics of light falloff at edges of the macro lens in the photographing magnifications m and n, respectively. FIGS. **3**A and **3**B are common in that the light quantity decreases according as the image height increases (toward the periphery of a screen from the center of the screen). However, the characteristics are different. Therefore, the optical correction value of the light falloff at edges to be used cannot be identified from the combination of focal length, photographing distance, and aperture value for at least one of the photographing magnifications m and n.

FIGS. **3**C and **3**D illustrate examples of results of correction using the optical correction value identified without consideration of the photographing magnification. In the examples, the light falloff at edges is appropriately corrected in the photographing magnification m. However, correction is insufficient and an appropriate correction is not performed in the photographing magnification n. Thus, an appropriate optical correction value sometimes cannot be independently determined by information about the focal length, photographing distance, and aperture value depending on the lens unit.

Information for identifying the photographing magnification is required to apply an appropriate optical correction to the image captured using the macro lens with the characteristic illustrated in FIG. **2**, for example. The photographing magnification can be automatically set by manual operation of the magnification change ring provided on the lens unit, for example. If the set photographing magnification is known, an appropriate optical correction value can be identified.

Thus, in the interchangeable lens imaging apparatus, optical parameter values required for identifying the optical correction value need to be obtained for each type of lens unit to apply an appropriate optical correction to images to be captured by various different types (models) of lens units.

[Processing for Determining Type of Interchangeable Lens]

FIG. **6** is a flow chart illustrating processing for determining the type of an interchangeable lens and processing for receiving an optical parameter which are performed by the camera microcomputer **20** in the present exemplary embodiment. The processing illustrated in FIG. **6** is performed by the camera microcomputer **20** executing the programs stored in the memory **16**.

In steps S**601** and S**602**, the camera microcomputer **20** reads the voltage values H or L of the MIF_IN terminal and a voltage value of the DTEF_IN terminal, respectively. The signals may be obtained in parallel from the MIF_IN and DTEF_IN terminals.

In step S**603**, if the voltage value of the MIF_IN terminal is L and the attachment of the interchangeable lens **100** is detected, the camera microcomputer **20** determines the type of the attached interchangeable lens **100** based on the voltage value (the AD conversion result) of the DTEF_IN terminal. If the camera microcomputer **20** determines that the attached interchangeable lens **100** is the first interchangeable lens (denoted as a lens type **1** in FIG. **6**) (YES in step S**603**), then in step S**610**, the camera microcomputer **20** sets the communication baud rate of the initial communication for the lens type **1**. In the present exemplary embodiment, it is assumed that a lens type **1** includes a lens adapted only to a low-speed baud rate communication and communication processing is performed at a low speed (step S**612** described below). In step S**611**, the camera microcomputer **20** outputs the high-level signal from the CNT_V_OUT terminal and sets the communication voltage to V**1**. The processing proceeds to step S**612**.

If the camera microcomputer **20** determines that the attached interchangeable lens **100** is the second interchangeable lens (denoted as a lens type **2** in FIG. **6**) (YES in step S**620**), then in step S**621**, the camera microcomputer **20** sets the communication baud rate of the initial communication for the lens type **2**. In the present exemplary embodiment, it is assumed that the lens type **2** includes a lens adapted to a high-speed baud rate communication and communication processing is performed at a high-speed (step S**612** described below). In step S**622**, the camera microcomputer **20** outputs the low-level signal from the CNT_V_OUT terminal and sets the communication voltage to V**2**. The processing proceeds to step S**612**. If the camera microcomputer **20** determines that the attached interchangeable lens **100** is neither the first interchangeable lens nor the second interchangeable lens (NO in step S**603** and step S**620**), then in step S**630**, the camera microcomputer **20** determines that the attached interchangeable lens **100** is an "unadapted lens" or reserves determination. The camera microcomputer **20** stops processing instead of starting communication with the attached interchangeable lens **100**. At this point, the camera microcomputer **20** may give a warning to the user.

In step S**612**, the camera microcomputer **20** starts communication with the interchangeable lens **100** at the set communication voltage and communication baud rate.

In step S**612**, the camera microcomputer **20** performs initial data exchange processing with the lens. Thereby, the camera microcomputer **20** obtains a lens ID as the individual information of the interchangeable lens **100** to acquire information about the type of the lens, indicating which function the attached interchangeable lens **100** is adapted to. Thereby, the camera microcomputer **20** functions as a lens information acquisition unit. The lens ID of the individual information is stored in the memory **104** being a lens information storage unit.

Information about the type of the lens includes information about whether a reset operation is required (described below in step S**631**), whether optical correction data can be obtained by communication (described below in step S**633**), and whether the lens is adaptable to a communication system synchronized with an imaging timing signal. Since an optical member which can be driven performs a posi-

tional control, the reset operation is a process operation for the lens control unit **103** detecting the reference position of the control. In the following description, the communication system synchronized with the imaging timing signal may be written as a moving image communication system and the communication system not synchronized with the imaging timing signal may be written as a still image communication system. In other words, the moving image communication system as a second communication system is a communication system that transmits a signal synchronized with a vertical synchronous signal corresponding to timing for reading an imaging signal from the sensor to the interchangeable lens **100**. This realizes a lens and diaphragm drive control synchronized with the image timing.

In step S**631**, the camera microcomputer **20** determines whether the lens can adapt to the reset operation based on the information about the type of the lens obtained in step S**612**. If the lens can adapt to the reset operation (YES in step S**631**), the processing proceeds to step S**632**.

[Reset Communication Processing 1]

FIG. **19** illustrates the processing in step S**632**. When the camera microcomputer **20** starts the reset communication processing, in step S**640** illustrated in FIG. **19**, the camera microcomputer **20** checks if the communication system is the moving image communication system. If the communication system is not the moving image communication system (NO in step S**640**), in step S**641**, a communication state is switched from the still image communication system to the moving image communication system.

This is because it is desirable to perform control synchronized with the imaging timing signal when the reset operation is performed as the processing for the lens. More specifically, this is because the interchangeable lens adapted to the moving image communication system often uses the communication system synchronized with the imaging timing of the camera. The interchangeable lens adapted to such a moving image communication system desirably communicates using the moving image communication system at the time of a live view to adapt to the imaging timing. During the communication using the moving image communication system, it may be necessary to perform the reset again due to the step-out of the lens unit. It is desirable to realize the reset operation of the lens to avoid the imaging timing. That is why the reset operation is executed in the moving image communication system.

[Example of Still Image Communication System]

As illustrated in FIG. **13**, the example of the still image communication system as the first communication system is a system that the camera microcomputer **20** functions as a master and transmits a control signal along with a clock signal to the interchangeable lens **100** at a predetermined timing.

[Example of Moving Image Communication System]

One of advantages of the moving image communication system is that the camera control unit **18** can easily perform control processing synchronized with the exposure time of the sensor **11**. In other words, the camera control unit **18** can share the imaging timing with the lens control unit **103**. This allows a focus control to be performed without using a contrast value (automatic focus (AF) evaluation value) of an image during the exposure time of the sensor **11**, for example. This enables control for wobbling in consideration of the exposure time of the sensor **11**.

In FIG. **14**A, the abscissa is the time axis and represents a frame interval and an exposure time. FIG. **14**B illustrates a communication processing between the camera control unit **18** and the lens control unit **103**, and the abscissa is the time axis. In FIG. **14**C, the abscissa is the time axis in the lens drive control and represents a stop period and the drive period of wobbling, and the ordinate is the position of the focus lens. FIG. **15** illustrates the communication processing including the first and the second communication illustrated in FIG. **14**B.

Two types of the communication processing of the first and the second communication with the fixed length for each exposure period corresponding to the frame related to the imaging signal are performed. The camera synchronizes the start timing of the first communication with the imaging timing signal and notifies the lens of the imaging timing. In this configuration, the first communication transfers the data that are desirably transferred at timing near the imaging timing, the control information is generated based on the information transferred by the first communication, and the control information is sent to the lens by the second communication, which allows completing the lens control during 1V (one imaging timing period).

[Reset Communication Processing 2]

In step S**641** in FIG. **19**, the communication system is switched from the still image communication system to the moving image communication system. In step S**642**, a request for starting the reset operation is transmitted to the lens by the moving image communication system. Thereby, the camera microcomputer **20** functions as a reset instruction unit. For example, the camera requests the lens to perform the reset operation by the first communication at the communication terminal Cout and the lens notifies the camera of a reset completion state by the first communication at the communication terminal Cin. At first, in the first communication, data are exchanged and the camera control unit **18** determines whether the reset operation of position control of the imaging lens **101** in the interchangeable lens **100** is uncompleted. If the reset operation is uncompleted, the camera control unit **18** requests the lens to start the reset operation by the first communication performed later at the communication terminal Cout and the camera is notified that the lens completes the reset operation from the DLC_IN terminal. In step S**642**, the camera waits for the response of the completion of the reset operation from the lens.

The camera may separately transmit the reset request for units forming the lens unit, such as a focus lens, an image stabilization (IS) lens, a zoom lens, and a diaphragm, to the lens. If the reset request can be thus separately transmitted, the unit whose reset operation is completed may sequentially transmit drive requests. In this case, the camera control unit **18** needs to sequentially perform processing. In the above processing, the camera requests the lens to start the reset operation by the first communication, and, in response to the above request, if the lens control unit **103** subjects the focus lens, the optical image stabilization lens, the zoom lens, and the diaphragm to the reset operation, the following advantages are obtained. The lens control unit **103** can previously store the characteristics of the interchangeable lens **100**, so that the lens control unit **103** can perform the reset operation in parallel with that. For example, if it takes a long time to perform the reset operation of the focus lens, the reset operation of the focus lens is started first, after that, the reset operation of the diaphragm and then the optical image stabilization lens is started, for example. A combination for performing the reset operation in parallel in view of power consumption may be stored.

The above description is performed on the assumption that communication on a request for the reset operation and the completion of the reset operation is performed by the

first communication. However, the communication may be performed by the second communication.

In step S643, recovery processing is performed from the moving image communication system to the still image communication system. However, if a default setting system of the communication system is taken as the moving image communication system, the present processing is not required. For example, in a case where a wobbling control is not required, such as a manual focus setting, it is desirable to return to the still image communication system. In this respect, in a case where the wobbling control is desired to be executed, such as an object tracking setting, the moving image communication system may be remained unchanged.

[Switching Processing]

The following describes switching processing from the still image communication to the moving image communication in step S641 and switching processing from the moving image communication to the still image communication in step S643.

The switching processing from the moving image communication to the still image communication is described below with respect to FIGS. 17A and 17B.

In step S1700, the camera starts processing. In step S1701, the camera control unit 18 sets 1 to a bit predetermined as communication regulations (communication protocol) in the moving image communication system and performs communication to transmit a request for finishing the moving image communication system to the lens.

In step S1702, the communication system is switched to the still image communication system. After the request for switching the communication system to the still image communication is transmitted to the lens in step S1701, even if a communication request from the camera system to the lens occurs in a predetermined time, the request is reserved in a predetermined time. In step S1703, the present request processing is executed using the still image communication system after the predetermined time elapses. This is because it is ensured that the communication reception state of the lens is switched to the still image communication system after the predetermined time elapses.

In step S1720, while the lens is operating in the moving image communication system, in step S1721, the next reception interruption processing occurs from the camera. In step S1723, the lens control unit 103 makes reference to a bit corresponding to the request for finishing the moving image communication system among the received data of the moving image communication system. If the bit is 0 (no request for finishing is made) (NO in step S1723), in step S1726, the lens waits for receiving the second communication to be transmitted from the camera. If the bit is 1 (a request for finishing is made) (YES in step S1723), in step S1724, the communication setting is switched to the still image communication system within the predetermined time and the lens operates on the assumption that the second communication is not performed.

The present processing is an operation that the camera and lens sides mutually expect that switching of the communication setting is completed by the elapse of the predetermine waiting time. This is because both sides do not need to newly check if the communication system is switched because the start timing of switching the communication is synchronized by the moving image communication system.

[Switching to Still Image Communication System]

The switching processing from the still image communication system to the moving image communication is described below with respect to FIGS. 18A and 18B.

In step S1730, the camera control unit 18 starts processing. In step S1731, the camera control unit 18 transmits a command predetermined as communication regulations in the still image communication system to the interchangeable lens 100 to request the interchangeable lens 100 to start the moving image communication.

In step S1732, after the camera control unit 18 transmits the request, the camera control unit 18 switches the communication system to the moving still image communication system. After the request for switching the communication system to the moving image communication is transmitted to the lens in step S1731, in step S1733, even if a communication request from the camera system to the lens occurs in a predetermined time, the request is reserved in a predetermined time. The present request processing is executed using the moving image communication system after the predetermined time elapses.

In step S1740, while the lens is operating in the still image communication system, in step S1741, the next reception interruption processing occurs from the camera. In step S1742, the lens control unit 103 determines whether the received data is a command for requesting the lens to start the moving image communication.

If the received data is the command for requesting the lens to switch the communication setting to the moving image communication (YES in step S1742), in step S1743, the lens control unit 103 switches the communication setting to the moving image communication system within the predetermined time.

In step S660, the camera microcomputer 20 determines whether imaging interruption occurs in which the imaging switch of the operation input unit 17 starts recording an image. If the imaging interruption does not occur (NO in step S660), the camera microcomputer 20 causes the processing to proceed to step S664. If the imaging interruption occurs (YES in step S660), in step S661, the camera microcomputer 20 communicates with the interchangeable lens 100 to acquire a first optical parameter.

As described above, the first optical parameter is information required for identifying the optical correction value of the interchangeable lens 100 of the lens type 1 and a basic optical parameter of the interchangeable lens 100 including information capable of identifying each of at least a focal length, a photographing distance, and an aperture value. Since the information is usable for processing in addition to the optical correction, in the present exemplary embodiment, the first optical parameter is acquired independent of the determined type of the lens. In other words, in the present exemplary embodiment, even if the second interchangeable lens is attached, the first optical parameter is acquired in step S661.

In steps S662 and S663, the camera microcomputer 20 acquires a second optical parameter from the interchangeable lens 100 if it is determined that the interchangeable lens 100 is the second interchangeable lens in step S603. The second optical parameter is an optical parameter required for identifying the optical correction value of the second interchangeable lens. Since the second optical parameter normally includes at least apart of parameters acquired as the first optical parameter, optical parameters different from at least the first optical parameter among the second optical parameters are acquired. In the present exemplary embodiment, the second optical parameter includes information capable of identifying at least the photographing magnification. If the second lens is a macro lens, the optical correction value can be identified from the photographing magnification and the aperture value. The aperture value is

already acquired as the first optical parameter, so that the aperture value does not need to be acquired in step S663. Thus, values overlapping with the first optical parameter among the second optical parameter do not need to be acquired again.

In step S664, the camera microcomputer **20** determines whether the interruption of turning off the power source by turning off the power source switch of the operation input unit **17** occurs. If the interruption of turning off the power source occurs (YES in step S664), the camera microcomputer **20** turns off the power source. If the interruption of turning off the power source does not occur (NO in step S664), in step S665, the camera microcomputer **20** determines whether the voltage of the MIF_IN terminal is at a high level, that is, the interchangeable lens **100** is detached from the camera **10**. If the voltage at a high level is input from the MIF_IN terminal (YES in step S665), then in step S666, the camera microcomputer **20** stops communicating with the interchangeable lens **100**. Then the camera **10** is stopped. If the voltage at a high level is not input from the MIF_IN terminal (NO in step S665), the camera microcomputer **20** returns the processing to step S660.

The camera control unit **18** performs such a communication processing to perform the communication processing adapted for the function of the attached interchangeable lens **100**, allowing the determination of the type of the attached lens and the acquisition of the optical parameters required for identifying the optical correction value of the attached interchangeable lens **100**.

The example illustrated in FIG. **6** describes the method for determining the type of the attached interchangeable lens **100** according to the voltage value input to the DTEF_IN terminal. However, other determination methods may be used. For example, the type of the lens may be determined by receiving information about the type of the lens immediately after the step S660 from the interchangeable lens **100** without determining the type of the lens in steps S601 and S602 and setting the output voltage and communication baud rate according to the type of the lens in steps S610 and S611 and steps S621 and S622.

An optical correction processing performed by the optical correction unit **130** is described below. FIG. **7** is a flow chart illustrating the optical correction processing performed by the optical correction unit **130**.

In step S100, the optical correction unit **130** acquires optical correction data including optical correction values corresponding to the interchangeable lens **100** used for imaging from a table of optical correction data stored in the memory **16**. From the viewpoint of the interchangeable lens **100**, this means that the stored optical correction data are transmitted. The memory **16** functions as an optical correction data storage unit.

The memory **16** stores the optical correction data table, which has a structure illustrated in FIG. **8** and stores optical correction data about a plurality of types of interchangeable lenses. An address information area in the head of the table records lens IDs being information for identifying the type of the interchangeable lens **100** and information for identifying the head address storing the corresponding optical correction data. A correction data area sequentially stores the optical correction data corresponding to each lens ID. As described below, the correction data area is structured such that an optical correction value about the interchangeable lens classified into the first interchangeable lens can be obtained from the first optical parameter and an optical correction value about the interchangeable lens classified into the second interchangeable lens can be obtained from the second optical parameter. The optical correction unit **130** searches for the ID of the interchangeable lens used for imaging in the address information area to acquire the stored optical correction data from the address acquired in the address information area.

In step S101, as described above, the optical correction unit **130** causes the processing to diverge based on results of determination of the type of the lens performed in steps S603 and S620 when the power source is turned on or the interchangeable lens **100** is interchanged. If the attached interchangeable lens **100** is the first interchangeable lens, in step S102, the optical correction unit **130** acquires an optical correction value from the correction data using the first optical parameter. If the attached interchangeable lens **100** is the second interchangeable lens, in step S103, the optical correction unit **130** acquires an optical correction value from the correction data using the second optical parameter.

FIG. **9**A illustrates a structure of the correction data corresponding to the first interchangeable lens. The correction data are formed of an address information area and a correction value area.

In FIG. **9**A, OptInfo**1**[*n*], OptInfo**2**[*m*], and OptInfo**3**[*p*] (where n, m, and p are integers of 0 or more) denote the arrangement of the following optical parameters that can be taken by the interchangeable lens.

OptInfo**1**[*n*]: focal length information

OptInfo**2**[*m*]: photographing distance information, and

OptInfo**3**[*p*]: aperture value information.

Information about values which substantially take continuous values, such as focal length and a photographing distance, may be stored with a predetermined discrete value as an arrangement value.

For the first interchangeable lens, each of combinations of the three optical parameters and information for identifying the storage address of the optical correction value corresponding to the combination are set in the address information area. The storage address is the one in the correction value area. The optical correction value corresponding to each of the combinations of the optical parameters is sequentially stored in the correction value area.

Therefore, reference is made to the address information area using the first optical parameter used for imaging to allow acquisition of the optical correction value from the correction value area.

FIG. **9**B illustrates a structure of the correction data corresponding to the second interchangeable lens. The correction data is formed of an address information area and a correction value area.

In FIG. **9**B, OptInfo**3**[*p*] and OptInfo**4**[*q*] (where p and q are integers of 0 or more) denote the arrangement of the following optical parameters that can be taken by the interchangeable lens.

OptInfo**3**[*p*]: aperture value information and

OptInfo**4**[*q*]: photographing magnification information.

For the second interchangeable lens, each of combinations of the two optical parameters and information for identifying the storage address of the optical correction value corresponding to the combination are set in the address information area. The storage address is the one in the correction value area. The optical correction value corresponding to each of the combinations of the optical parameters is sequentially stored in the correction value area.

Therefore, reference is made to the address information area using the second optical parameter used for imaging to allow acquisition of the optical correction value from the correction value area.

FIG. **10** illustrates an example of the optical correction value stored for each of the combinations of the optical parameters in FIGS. **9**A and **9**B. Examples of correction values of light falloff at edges are illustrated here. The values of optical quantity for discrete image-heights h**0** to h**4** are stored as the optical correction value to reduce storage capacity. Discrete optical correction values are approximated by a polynomial expression to produce a correction curve, thereby the correction value for any image height can be obtained.

Thus, the optical correction values are stored for each combination of optical parameters required for identifying the optical correction quantity according to the lens type and lens model (ID). The optical parameters stored in the address information area may also be discretely combined, and as for the combination not stored therein, a plurality of correction values corresponding to the combination of approximate values is interpolated to allow generation of the optical correction value.

A correction method using image processing is described below with the light falloff at edges as an example. An image height being a distance from the image center in each pixel of image data to be corrected is acquired first and then light quantity corresponding to the image height is acquired from the correction curve. A gain corresponding to the reciprocal number of the light quantity is applied to a pixel value. Such processing is applied to all pixels of the image data to allow correction of the light falloff at edges.

FIGS. **11**A, **11**B, **11**C, and **11**D illustrate the characteristics of light falloff at edges of the macro lens and examples of results of correction to which the method of the present exemplary embodiment is applied, similarly to FIGS. **3**A, **3**B, **3**C, and **3**D. FIGS. **11**A and **11**B illustrate the characteristics of light falloff at edges of the macro lens in the photographing magnifications m and n, respectively, and are similar to FIGS. **3**A and **3**B.

Unlike the examples of results of correction using the optical correction value identified without consideration of the photographing magnification, illustrated in FIGS. **3**C and **3**D, the present exemplary embodiment performs correction using the optical correction value in consideration of the photographing magnification. For this reason, as illustrated in FIGS. **11**C and **11**D, brightness is equal to approximately 100 in all image heights independently of the photographing magnification to enable acquisition of a high-accuracy correction image.

The method for correcting the light falloff at edges is described above as an example of an optical characteristic resulting in image degradation. However, similarly to the light falloff at edges, a basic method, in which a correction curve is formed from a discrete combination of image height and correction quantity corresponding to the combination of optical parameters and a correction value according to the image height is acquired to perform correction, is common to other optical characteristics, such as distortion aberration and chromatic aberration of magnification.

Thus, according to the present exemplary embodiment, the type of the lens unit different in the combination of optical parameters required for identifying the optical correction value is determined and the appropriate optical parameter adapted for the type of the lens unit is acquired to identify the optical correction value. For this reason, the present exemplary embodiment can realize a higher accurate optical correction than a convention technique, which acquires an optical correction value from the combination of common type of optical parameters independently of the type of the lens unit.

In the present exemplary embodiment, for the sake of simplifying description and facilitating understanding, there are described two types of lens units to be determined (or the combination of optical parameters required for identifying the optical correction value). However, the lens units and the combination of the optical parameters are not limited to two types, but the present exemplary embodiment is applicable to a larger number of types.

For example, there has been described an example, in which the present exemplary embodiment uses a macro lens as a lens unit with the second optical parameter and has information about position of a mechanism for changing a photographing magnification as the second optical parameter. However, the lens unit with the second optical parameter has not necessarily to be the macro lens and the second optical parameter may be information about position of an optical member for controlling a focal length or a photographing distance. The term "information about position of an optical member" is information about position of a mechanism for driving a lens to change a focal length or a photographing distance. The information about position of the optical member for controlling a focal length (units in mm) or a photographing distance (units in cm) acquired as the second optical parameter instead of a focal length or a photographing distance acquired as the first optical parameter may be used for identifying the optical correction value. In a system whose resolution of information about position of the optical member is higher than that of a focal length (units in mm) or a photographing distance (units in cm), the information about position of the optical member is used to realize a high-accuracy optical correction.

A second exemplary embodiment of the present invention is described below.

A basic configuration of an imaging apparatus according to the present exemplary embodiment and the terminals provided on the mount **1** are similar to those described in the first exemplary embodiment. However, the second interchangeable lens in the present exemplary embodiment is configured to transmit optical correction data from the lens to the camera. For this reason, the optical correction data is stored in the memory **104** of the second interchangeable lens. The optical correction data stored therein has a structure illustrated in FIG. **9**B.

FIG. **12** is a flow chart illustrating processing for determining the type of an interchangeable lens, processing for receiving optical correction data, and processing for receiving optical parameters in shooting required for identifying the optical correction value which are performed by the camera microcomputer **20** in the camera system according to the present exemplary embodiment. The processing illustrated in FIG. **12** is performed by the camera microcomputer **20** executing programs stored in the memory **16**. In FIG. **12**, the steps which perform processing similar to the processing illustrated in FIG. **6** according to the first exemplary embodiment are given the same reference numerals and the description thereof is not repeated.

Although the processing illustrated in FIG. **12** is basically similar to the processing in the first exemplary embodiment, the processing in FIG. **12** is different in that the camera microcomputer **20** communicates with the interchangeable lens **100** in step S**633** to acquire the optical correction data after the camera microcomputer **20** determines that the attached interchangeable lens **100** is the lens type **2** in step S**603**, switches the communication baud rate to an appropriate communication setting in steps S**621** and S**622**, and executes communication in step S**612**. The processing transmits the optical correction data stored in the memory **104** of

the interchangeable lens **100** to the camera **10** and stores the data in the memory **16** of the camera **10**. The transmitted optical correction data has a data structure illustrated in FIG. **9**B and is set so that the optical correction value can be identified from the first optical parameter acquired in step S**661** and the second optical parameter acquired in step S**663**.

[Communication for Acquiring Optical Correction Data]

The camera microcomputer **20** determines whether the attached lens is the lens type **1**.

If the attached lens is the lens type **2** (YES in step S**633**), in step S**634**, processing for the optical correction data acquiring communication is performed.

In step S**634**, when the optical correction data acquiring communication is started, in step S**650**, the camera microcomputer **20** checks whether there is a need for the camera **01** to acquire the optical correction data of the attached interchangeable lens **100**. If the optical correction data corresponding to the attached interchangeable lens **100** is already stored in the memory **16**, the processing may be omitted. This allows saving of processing time required for communication of the optical correction data if the camera **10** already has the optical data.

In this step, a determination is made as to whether the information acquired in step S**612**, the information stored in the memory **16**, and the information about the attached lens coincide with one another. The above pieces of information include lens type information and lens name acquired in step S**612**, the serial number of the lens, the presence or absence of accessories such as extender, and version information for identifying the format of the optical correction data.

Communication for the optical correction data is described below with reference to FIG. **20**.

In step S**650**, if the camera microcomputer **20** determines that the optical correction data needs to be acquired (YES in step S**650**), in step S**651**, the camera microcomputer **20** checks if the present communication system is the moving image communication system. If the present communication system is the moving image communication system (YES in step S**651**), in step S**652**, the camera microcomputer **20** switches the communication state into the still image communication system. The reason the communication state is switched from the moving image communication system into the still image communication system is that a blank period occurs between the two communications with fixed length in the moving image communication system as illustrated in FIG. **14**. In other words, if optical correction data with a larger amount of data is transferred, it takes a relatively longer time due to the blank period, so that the moving image communication system is inferior to the still image communication system.

In step S**653**, the camera microcomputer **20** sequentially acquires the optical correction data from the lens and stores the optical correction data in the memory of storage area of the camera.

FIG. **16** illustrates examples of methods for acquiring the optical correction data and storing data. As described above, because data size is large like the optical correction data and all data need to be collectively acquired, it is desirable to acquire data on the still image communication. The communication processing in this step performs only data transfer and does not perform a lens drive control. Thus, both of the camera and the lens do not have to allocate the processing function of the microcomputer to communication control, or data transfer is performed by a direct memory access (DMA) function without a central processing unit (CPU). That eliminates the need for passing thorough BUSY time between the communications as illustrated in FIG. **16**, allowing the speed of communication to be increased. The camera has only to output a fixed value to the communication terminal Cout because of communication whose purpose is to acquire data. The information about the optical correction data acquired at the communication terminal Cin has only to be transferred to the predetermined memory **16** each time the information is acquired. For the sake of convenience, FIG. **16** indicates that data transfer processing to the memory **16** occurs each time X-byte data is acquired. However, the communication data size does not need to be limited to X byte.

In step S**653**, the communication system is returned to a state suited to camera operation similarly to step S**643**. The reason a reference is made to the voltage value at the DTEF_IN terminal in step S**602** as a determination condition in step S**633** is that the camera microcomputer **20** is enabled to acquire the optical correction data forward during starting time before the initial data exchange processing is performed with the lens in step S**612** if there is time to spare. The information about type of the lens in step S**612** may be configured to acquire whether it is possible to communicate the optical correction data, which may be taken as determination object in step S**633**.

Thus, the optical correction data is acquired after the lens reset operation is executed. This is because the lens reset operation is preceded to accelerate a live view displaying an object image to executable state.

A table of the optical correction data stored in the memory **16** has a structure illustrated in FIG. **8**. The optical correction data received from the interchangeable lens **100** needs to be added to the table for future reference. As described above, if the interchangeable lens **100** is detached and then attached again, the processing passes step S**666** and returns to step S**660** to perform repeat processing.

The optical correction data for the second interchangeable lens is acquired and the optical parameter for identifying the correction value from the acquired optical correction data is acquired through the above processing.

The optical correction processing performed by the optical correction unit **130** may be the same as that of the first exemplary embodiment. The optical correction data acquired from the second interchangeable lens are already stored in the memory **16**, so that the processing illustrated in FIG. **7** is performed to allow identification of the correction value and performance of the correction processing.

As described in the present exemplary embodiment, the optical correction data is transmitted from the lens unit to the camera, stored therein, and used for identifying the optical correction value to enable appropriate optical correction even if the optical correction data corresponding to the attached lens unit is not stored in the memory **16**.

In the present exemplary embodiment, the second interchangeable lens transmits the optical correction data to the camera. However, exemplary embodiments of the present invention are not limited to such an embodiment. A plurality of different types of interchangeable lenses may transmit the optical correction data to the camera. The types of the lenses transmitting the optical correction data to the camera and the combinations of optical parameters required for the types of the lenses are also not limited to those described in the present exemplary embodiment, but the exemplary embodiments of the present invention are applicable to a plurality of types and combinations.

The exemplary embodiments are described above in which the present invention is applied to the imaging apparatus with a specific configuration. The exemplary

embodiments of the present invention can be modified and changed in a variety of ways without departing from the scope of the claims.

The exemplary embodiments of the present invention can provide a technique for switching to a communication system appropriate for an attached lens unit for communication between a camera and the lens unit.

Embodiments of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions recorded on a storage medium (e.g., non-transitory computer-readable storage medium) to perform the functions of one or more of the above-described embodiment(s) of the present invention, and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more of a central processing unit (CPU), micro processing unit (MPU), or other circuitry, and may include a network of separate computers or separate computer processors. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2012-200298 filed Sep. 12, 2012, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An imaging apparatus, to which a lens unit with an optical member is attached and which communicates with the lens unit to transmit a control signal for the optical member, the imaging apparatus comprising:

at least one processor;

at least one memory;

a communication unit configured to communicate with the attached lens unit;

an imaging unit configured to be able to capture an object image formed by the optical member of the attached lens unit;

a lens information acquisition unit configured to acquire, via the communication unit, individual information of the attached lens unit;

a determination unit configured to determine a communication method with the attached lens unit;

and a reset instruction unit configured to instruct, via the communication unit, the attached lens unit to reset the optical member thereof,

wherein the lens information acquisition unit acquires the individual information of the attached lens unit in a first communication method which does not use a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus, thereafter the reset instruction unit instructs to reset the optical member in a second communication method which uses a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus, and thereafter the lens information acquisition unit acquires, via the communication unit, optical correction data of the attached lens unit in the first communication method,

and wherein at least one of the units is implemented upon execution of the instructions stored in the at least one memory by the at least one processor.

2. The imaging apparatus according to claim **1**, wherein the first communication system does not use a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus.

3. The imaging apparatus according to claim **1**, wherein the second communication system uses a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus.

4. The imaging apparatus according to claim **1**, wherein, the communication with the attached lens unit, after the optical correction data is acquired, is switched to the communication not using the signal corresponding to the imaging timing signal of an image sensor of the imaging apparatus.

5. A lens unit exposing an object image on an imaging apparatus including an imaging unit capable of capturing the object image, the lens unit comprising:

at least one processor;

at least one memory;

an optical member capable of being driven;

a communication unit configured to communicate with the imaging apparatus, to which the lens unit is attached;

a memory configured to store individual information;

a setting unit configured to set a communication system with the imaging apparatus;

a reset unit configured to reset a driving of the optical member; and

an optical correction data storage unit configured to store optical correction data,

wherein the individual information stored in the memory is, via the communication unit, transmitted to the imaging apparatus in a first communication method which does not use a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus, thereafter the reset unit resets the driving of the optical member in response to an instruction via the communication unit in a second communication method which uses a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus, and thereafter the optical correction data stored in the optical correction data storage unit is, via the communication unit, transmitted in the first communication method, and

wherein at least one of the unit is implemented upon execution of the instructions stored in the at least one memory by the at least one processor.

6. The lens unit according to claim **5**, wherein the first communication method does not use a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus.

7. The lens unit according to claim **5**, wherein the second communication method uses a signal corresponding to an imaging timing signal of an image sensor of the imaging apparatus.

8. The lens unit according to claim **5**, wherein the communication with the imaging apparatus, after the optical correction data is transmitted, is switched to the communication not using the signal corresponding to the imaging timing signal of an image sensor of the imaging apparatus.

9. The lens unit according to claim 5, wherein the individual information stored in the memory and the optical correction data are, via the communication unit, transmitted to the imaging apparatus.

10. The imaging apparatus according to claim 1, wherein the imaging apparatus performs image processing on an image with the optical correction data.

11. The lens unit according to claim 5, wherein the imaging apparatus performs image processing on an image with the optical correction data.

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